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LONDON AND THE ADVANCEMENT OF SCIENCE

BY VARIOUS AUTHORS

ISSUED BY THE BRITISH ASSOCIATION FOR THE
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OF ITS CENTENARY MEETING IN LONDON, 1931

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PREFACE

THIS book originated in a suggestion made by Dr. Allan Ferguson, which was given effect by the Council of the British Association for the Advancement of Science, by whom it was ordered to be prepared for issue at the Centenary Meeting of the Association in London, September 23-30, 1931, the secretary being charged with the editorship. The thanks of the Association are due to the collaborating authors, and also to the authorities of the societies who furnished the information upon which are based the brief particulars given in Chapter III. The editor desires gratefully to acknowledge the co-operation of Mrs. Howarth in the compilation of that chapter, and of the index, and to thank Dr. Allan Ferguson and Sir Frank Heath especially for valuable advice on many details.

London's scientific field is wide, and so far as appears has not been previously the subject of a comprehensive survey. Nor is it possible fully to achieve one within the necessary limits of this volume; but it is hoped that it may have some permanent value for reference; the editor will be glad, therefore, to be informed of any omissions or errors.

O. J. R. HOWARTH,
Secretary, British Association.

Burlington House,
London, 1931.

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LONDON AND THE ADVANCEMENT OF SCIENCE

CHAPTER I

INTRODUCTORY SURVEY

By ALLAN FERGUSON, M.A., D.Sc.

WHAT part should we look to the capital city of a great nation to play in the advancement of scientific knowledge? The answer is neither easy nor obvious, and its terms depend to a great extent on the age concerning which the question is asked. Certainly, we should expect the capital, the centre of government, a focus of the nation's trade, to draw to itself a great deal of what is richest in the national culture, in science, in art, and in literature. But it by no means follows, in this twentieth century at least, that the fundamental advances in scientific thought (which, indeed, can hardly be discussed in geographical terms) are necessarily to be associated with the capital.

There is in modern science, however, an immense and growing mass of highly technical work, concerned for the most part, directly or indirectly, with the amenities which science has brought into our civilisation, and to be followed in the records of the great professional institutions, the medical research schools, our national laboratories and observatories, and the research laboratories of certain of the leading industrial corporations. In the work of these bodies, and in the development of certain branches of cosmical physics, *problems arise which can be attacked satisfactorily only by team work on a large scale.* Moreover, the details (*ce superflu, si nécessaire*) of the developments of the sciences involve an amount of mathematical and laboratory work which daily increases in volume and complexity. Work of this type, together with much of the discussion and criticism of pioneer and revolutionary ideas, inevitably centres in the capital. Of such discussion it may happen that on occasion ideas of fundamental importance are engendered, but the fact remains that scientific team work and the detailed and invaluable results that accrue from the researches conducted in and by institutions of national importance, are typical of the activities which we naturally associate with the scientific life of a capital city.

It was otherwise in an earlier and simpler period, when the world was less mechanised, when character was in less danger of standardisation, when detail had not assumed such immense importance, and a Humboldt could still take all knowledge for his province. Scientific life in London had its own well-marked individuality, an individuality which still survives in such institutions as the Royal Institution, but is hardly characteristic of our own (possibly) more efficient age.

A convenient *terminus a quo* for our survey of London's earlier contributions to the advancement of science is provided by a remarkable and not too well-known fact. Asked to name the outstanding English writer of the middle ages—indeed, the earliest writer commonly recognised as English—

most of us would naturally name Geoffrey Chaucer (*c.* 1340-1400). And the remarkable fact is that *Chaucer, whose life is so closely linked with London, was an accomplished astronomer, and the author of* what was, until quite recent years, a standard English treatise on the astrolabe.

This fascinating instrument, invented by Hipparchus about 150 B.C., was, until close on the eighteenth century, an important part of the equipment of a navigator or astronomer. Essentially it is a graduated circle, which may be hung vertically, and carries a sighting rod for measuring the angular elevation of a heavenly body under observation. But it is much more than this. It is provided with a plane projection of altitude and azimuth circles over which is placed an open-work metal plate capable of rotation. Certain projecting points on this plate are so placed as to coincide with the projections of the more prominent stars, and the ecliptic is projected as a circle on which the position of the sun is marked from day to day. It thus becomes possible, after observing the altitude of a heavenly body (the sun included), to set the plate over the marked altitude and azimuth circles so as to give the aspect of the heavens at the time of observation. It is obvious then that the astrolabe permits of the solution of many of the astronomical problems (some of them relatively complex) that are included in a course on 'the study of the globes.' Let us, however, hear Chaucer himself. His treatise on the astrolabe, which is an expansion of Messahala's *Compositio et Operatio Astrolabie*, was composed for the benefit of his son Lewis, who had addressed to his father a 'bisi preyere . . . . to lerne the tretis of the astrelabie.' Here, *ex. gr.*, are his explicit directions for taking an altitude:—

'Put the ring of thin Astrelabie upon thi riht thowmbe and turne thi lift side agayn the liht of the sonne. And remeve thi rewle up and down til that the stremes of the sonne shyne thorgh bothe holes of thi rewle. Loke thanne howe many degrees thi rewle is a-reised fro the litel crois upon thin est line, and tak ther the altitude of thi sonne. And in this same wyse maistow knowe by nyhte the altitude of the Mone, or of brihte sterres. This chapitre is so general ever in on, that ther nedith no more declaracion; but forget it nat.'

One of the most important of the problems which confronted the mediæval navigator or explorer was that of the determination of his latitude. Obviously at the North Pole, the pole-star, or rather the pole, is directly overhead, and at the Equator the pole is on the horizon; in general, as a simple diagram shows, the angular altitude of the pole at any place is equal to the latitude of that place. Hence the importance of Chaucer's 'Conclusioun to prove the heyhte of the pool Artik fro the orisonte.'

'Tak any sterre fixe that nevere dissendith under the Orisonte in thilke regioun, and consider his heiest altitude and his lowest Altitude fro the Orisonte; and make a nombre of both thise altitudes; tak thanne and abate half that nombre, and tak ther the elevacioun of the pol Artik in that same Regioun.'

The whole treatise is written in the same spirit of competent and accurate knowledge which illumines Chaucer's most casual astronomical references. Turn, for example, to the opening lines of the *Prologue* and read:—

Whan that Aprille with his schowres swoote
The drought of March hath perced to the roote,
And bathed every veyne in swich licour,
Of which vertue engendred is the flour;
Whan Zephirus eke with his sweete breeth
Enspiréd hath in every holte and heeth
The tendre croppes, *and the yonge sonne*
Hath in the Ram his halfe-cours i-ronne . . . . ,

His *half-course*, mark, not half his course, which is a very different matter. Chaucer evidently intends to mark the time of the opening of his story with some exactness, and, as his opening lines show, April was well advanced. But, in Chaucer's time—indeed, as he himself points out in his treatise on the astrolabe—the sun entered Aries on March 12, and if we interpret the last line quoted as meaning that the sun had run *half his course* in the Ram, the date is obviously the end of March. Earlier commentators found difficulty in reconciling this with the words of the opening couplet; but the difficulty vanished if the term *half-course* is taken at its face meaning. The sun enters the Ram on March 12; by the end of March the sun has run half his course in the Ram; during April he runs a half-course in the Ram, and a half-course in the Bull; the last line quoted tells us that the sun has completed his half-course in the Ram; and the date of the opening of the pilgrimage is fixed, in accordance with the phrasing of the opening couplet, as about the twelfth of April.

The treatise on the astrolabe was written in 1391; we should like to think that Chaucer wrote it in his house above Aldgate, hard by the Minories, along which he must often have walked to the Customs House. The probability is that at that time Chaucer was living in Westminster.

Chaucer's contribution to the advancement of science was notable, and London may very well take pride in it; but the next event which we chronicle in this rapid survey is even more important, for the year 1570 saw the appearance of the first printed English Euclid. The event is closely associated with London; for both translator and printer, as is evident from the title page and colophon, which we here reproduce, are citizens of London.

The Elements
of Geometrie
of the most aunci-
ent Philosopher
Euclide
of Megara
faithfully (now first) tran-
slated into the English toung, by
H. Billingsley, Citizen of London.
Whereunto are annexed certaine
Scholies, Annotations and Inventi-
ons, of the best Mathematici-
ans, both of time past, and
in this our age.

With a very fruitfull preface made by M. J. Dee specifying the chief Mathematical Sciences, what they are, and whereunto commodious; where, also,

are disclosed certain new Secrets Mathematicall
and Mechanicall, untill these our daies, greatly
missed

At London
Printed by John Daye, dwelling
over Aldersgate beneath S. Martins.
These Bookes are to be solde at
his shop under the gate
1570

Henry Billingsley, the date of whose birth is uncertain, was entered at St. John's College, Cambridge, in 1551. If Wood's authority be any guide his mathematics do not originate from Cambridge but were acquired during a residence at Oxford where his teacher was an Austin friar of the name of Whitehead.

Billingsley, who had been apprenticed to a haberdasher, rose rapidly to fortune; he was sheriff of London in 1584, Lord Mayor in 1596, and member of parliament for London in 1603. He died in 1606 and was buried in the church of St. Catherine Coleman. He touched the life of London at many points and was, during this period, one of her most distinguished citizens. It has been suggested—the suggestion probably arises from an instinctive feeling that Billingsley's ordinary avocations had little relation to the minutiæ of leisured scholarship—that his Latinity and mathematics were not competent to the task of translating his original, the Latin version of Campanus, published in 1482 and 1509.

The name of John Dee, the astrologer and writer of the 'fruitfull preface,' has been put forward as that of the real author, but if Dee's own testimony may be quoted on the point he is perfectly definite. He states that besides the introduction he contributed *only* 'Divers and many annotations and inventions mathematicall added in sundry places of the aforesaid English Euclide after the tenth booke of the same.'

Dee's preface is a remarkable piece of discursive writing, which rises on occasion to a height of real eloquence. One oft-quoted passage may be repeated again to-day, all the more aptly inasmuch as it was a favourite with the late Canon J. M. Wilson, whose recent death we have to deplore. Roused by Plato's remark that geometry is the knowledge of that which is eternal, Dee continues:—

'This was Divine Plato his judgment both of the purposed, chief and perfect use of geometry ..... And for us Christian men a thousand thousand more occasions are to have need of the help of megethological contemplations, whereby to train our imaginations and our minds, by little and by little, to forsake and abandon the gross and corruptible objects of our outward senses, and to apprehend, by sure doctrine demonstrative, things mathematical.'

The printing of our English Euclid brings us to a period of intense and vital activity in the history of science. Already Copernicus had published in 1543 his *De Revolutionibus Orbium Celestium*, which, although it had not escaped from the tyranny of 'cycle on epicycle, orb on orb,' yet smoothed the way for the calculations of Kepler, and so for Newton's generalisations. In 1545 appeared Cardan's *Ars Magna* containing advances of great importance in the theory of equations—even including a discussion of imaginary roots—and the great systematic work *De Plantis* by Cesalpinus appeared in 1583. Tycho was entering on that magnificent series of observations which provided the basis for Kepler's speculations, and ere the end of the century Galileo had carried out his experiments on falling bodies at Pisa. The year 1560 saw the establishment at Naples of the *Academia Secretorum Naturæ*, the first of a flood of societies for the investigation of topics of physical science.

London was in the forefront of this movement, and her contributions were of primary importance. There is no more typical example of the outlook of this period, in its devotion to experiment, its enthusiasm for positive science, and its contempt for the scholastic philosophy, than Gilbert's great work on the magnet. Gilbert of Colchester (1540-1603), whose position as physician to Queen Elizabeth left him time and opportunity for research, published his *De Magnete* in London in 1600. He calls on modern philosophers to quit 'the sort of learning that comes only from books and that rests only on vain arguments from probability and conjecture,' and by example as well as precept, shows far more clearly than Bacon the true method for the advancement of learning, loth though he is to submit his new philosophy to 'the most senseless corrupters of the arts, to lettered clowns, grammatists, sophists, spiriters, and the wrong-headed rabble to be denounced, torn to tatters, and heaped with contumely.' His outstanding discovery that the earth is a great magnet is illustrated by experiments made with a *terrella* or globular lodestone and a small magnet. He is not forgetful of, and dismisses caustically, his predecessors' explanations. The needle turns to the pole of the zodiac; to the celestial poles; to a star in the tail of Ursa Major; and so forth. 'So,' says Gilbert, 'has ever been the wont of mankind; homely things are vile; things from abroad and things afar are dear to them, and are the object of longing.'

That there is a declination of the needle from the geographical north had long been known, as was the fact that the declination varied from place to place. For long after Gilbert's day attempts were made to correlate declination and longitude—so late as the mid-eighteenth century Johnson contributed a preface to the work by Zachariah Williams printed in 1755 and entitled *An Account of an Attempt to ascertain the Longitude at Sea, by an exact Theory of the Variations of the Magnetic Needle* .....

But Gilbert was emphatic in asserting that no such connection exists, and that it is impossible to deduce longitude from a knowledge of declination. He was, however, of the opinion that there was no change of declination with time at any one place, a conclusion which, it is interesting to note, was corrected by Henry Gellibrand, professor at the Gresham College, an institution whose history will be discussed later.[1]

In the reaction against the scholastic outlook, Gilbert, along with Galileo and Harvey, played a pioneer's part. Gilbert, as we have seen, could express his views with considerable vivacity and directness. William Harvey (1578-1657) was more phlegmatic in temperament, if the tale be true that, at the battle of Edgehill he sate him down in the shelter of a hedge, took a book from his pocket, and continued to read, undisturbed by the tumult about him. The modest and kindly tone of the preface to his *magnum opus* is a model to all who are engaged in presenting a controversial subject, even though they seldom reach such a standard of disinterestedness as is shown in Harvey's statement that 'the studious and good . . . never suffer their minds to be warped by the passions of hatred and envy which unfit men duly . . . to appreciate the proposition that is even fairly demonstrated; neither do they think it unworthy of them to change their opinion if truth and undoubted demonstration require them to do so.'

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[1] **See Chapter IV, p. 146.**

Harvey and Harvey's work are intimately associated with London. He owed his education to Cambridge, and above all, to Padua, where he studied under the great anatomist Fabricius. Returning to England in 1602 he, after graduating M.D. at Cambridge, took a house in the parish of St. Martin-*extra*-Ludgate. In 1604 he was married at the church of St. Sepulchre. Shortly after being given the reversion of the office of physician to St. Bartholomew's hospital he was (in 1609) elected to this office, his duties being to attend the hospital 'one daye in the weeke at leaste thorough the yeare, or oftener as neede shall requyer.'

Although it was not until 1628 that he published at Frankfurt his *Exercitatio Anatomica de Motu Cordis et Sanguinis in Animalibus*, he had publicly announced his discovery of the circulation of the blood in lectures delivered in 1616. These lectures, the notes of which are preserved in the British Museum, were given at the College of Physicians in Knightrider Street, hard by St. Paul's, and were consequent on his election as Lumleian lecturer at the College in 1615.

Harvey's connection with the College was long, affectionate, and intimate. He added much in the way of equipment and buildings to the College, and in the year before his death endowed it with his paternal estate. The Harveian oration fittingly marks his great contribution to science and his generosity to his College.

Neither Harvey nor Gilbert was a systematist in the matter of scientific method. But their *obiter dicta* are of more value than the considered discourses of many a methodologist of high repute. Harvey's great work, in particular, written as it is in brief chapters which discuss the evidence *pro* and *con* for point after point, then marshal the argument and point its direction, bears on every page the stamp of the thinker and teacher. His views on scientific method are admirably and tersely put in his later work *De Generatione Animalium*: 'Sensible things are of themselves and antecedent; things of intellect, however, are consequential and arise from the former . . . . and hence it is that without the due admonition of the senses, without frequent observation and reiterated experiment, our mind goes astray after phantoms and appearances. Diligent observation is, therefore, requisite in every science, and the senses are to be frequently appealed to. We are, I say, to strive after personal experience, not to rely on the experience of others; without which indeed no one can properly become a student of any branch of natural science.'

Admirably put in 1651. Contrast these views with those of a prominent educationist of the mid-nineteenth century, at a time when laboratory teaching was forcing itself into the university curriculum. He took the attitude that a student who desired to see a phenomenon for himself and was unwilling to take the word of his tutor (often a clergyman of high intellectual standing) was exhibiting a peculiarly unpleasant and undesirable state of mind.

A sketch of Harvey's attitude to the general problems of scientific method leads to the very difficult question of the part played by Francis Bacon in the advancement of science. Bacon's scientific reputation, like his life, has oscillated from one extreme to the other. In Puffendorff's assessment as the man who 'raised the standard and urged on the march of discovery, so that if any improvement have been made in philosophy in this age there has been not a little owing to that eminent philosopher,' and in Harvey's as a Lord Chancellor who 'writes philosophy like a Lord Chancellor,' we see how, even in his own century, the extremes of criticism exist. This wide difference of opinion has persisted down to our own day, and any attempt to show in detail the reason for its existence would take us far beyond the limits of a sketch so brief as this. Much of the aloofness of present-day opinion is not unremotely connected with the influence of Macaulay's famous essay, which, brilliant though it may be, is deplorably lacking in delicacy of analysis. There are no half lights in a picture by Macaulay, and to estimate fully and fairly the tortuosities of a character so complex as Bacon's was a task for which Macaulay had little sympathy.

A difficulty, by no means small, lies in the unsystematic character of Bacon's philosophical work, its great amount, and, spread as it is over a long period of time busied with other cares, anxieties and ambitions, its inevitable repetitions. We can do no more here than to analyse certain portions of the writings of Bacon which form part of his scheme, the Great Instauration, and illustrate most aptly Bacon's outlook and method. His place in the history of education in London will bring us back to him in Chapter IV.

When he wrote the *Advancement of Learning* in 1605 it does not seem that he regarded it as an integral portion of the Great Instauration, though its later and more developed version the *De Augmentis Scientiarum* (1623) may stand as an introduction thereto. The second, and from our point by far the most important part of the Great Instauration, is the *Novum Organum*, written in 1620, which professes to give a canon for the interpretation of nature. The *Novum Organum* is itself incomplete, and with the remaining parts of the Great Instauration, fragmentary as they are, we need not concern ourselves. The titles of the sections (3) *Phænomena Universi*, (4) *Scala Intellectus*, (5) *Prodromi, the Forerunners, or Anticipations of the New Philosophy*, and (6) *Philosophia Secunda, or Active Science*, will serve to indicate the territory which Bacon would fain have conquered, but which, for the most part, was placed 'above my strength, and beyond my hopes.'

What are the characteristics of Bacon's method as expounded in the *Novum Organum?* 'The course I propose for the discovery of sciences is such as leaves but little to the acuteness and strength of wits, but places all wits and understandings nearly on a level, for as in the drawing of a straight line or a perfect circle much depends on the steadiness and practice of the hand if it be done by aim of hand only, but if with the aid of ruler or compass, little or nothing; so is it exactly with my plan.' When he writes thus we feel that he is entering on a scheme which is foredoomed to failure. And when we recollect that, unmetaphysical as his mind was, and concerned with the practical issues of knowledge, he none the less completely failed to estimate correctly some of the most striking researches of his age, it is tempting to pass a facile judgment of condemnation and to leave to others the task of disentangling truth from error in the thousand and more closely printed pages which contain Bacon's philosophical work.

Resisting the temptation, let us proceed with the analysis of his method. The first essential is the collection of the relevant facts. 'Man,' says Bacon in the opening sentence of the *Novum Organum*, 'as the Minister and Interpreter of Nature, does and understands as much as his observations on the order of Nature, either with regard to things or the mind, permit him, and neither knows nor is capable of more.'

Suppose then that we are investigating the *form* of a given *Nature*—we here use Bacon's own terminology and illustrate it, without entering into an over-long explanation, by assuming, as Bacon does, that the investigation is concerned with the *form* of the Nature which we call *Heat*. We must first form a "Table of Existence and Presence,' that is, 'we must present to the Understanding all the known Instances which agree in the same nature though the subject matter be considerably diversified. Next we must present to the Understanding Instances which do not admit of the given Nature; this we are wont to term a Table of Deviation or of Absence in proximity.'

'In the Third place we must exhibit to the Understanding the instances in which that Nature which is the object of our enquiries is present in a greater or less degree either by comparing its increase or decrease in the same object or its degree in different objects ..... We are wont to call this our table of degrees or comparative instances.'

These tables having been formed, 'Induction itself is to be brought into action.' The work of induction 'is rejection or the Exclusive Instances of Individual Natures which are not found in some one instance where the given Nature is present, or are found in any one instance where it is absent, or are found to increase in instances where the given Nature decreases or the reverse. After an exclusion properly effected, the *affirmative form* will remain as the residuum, solid, true, and well defined, whilst all volatile opinions go off in smoke.'

Such are the essentials of the Baconian method. Tables are drawn up by Bacon, in which he takes *Heat* as the Nature to be investigated, and arrives at his famous (and fortunate) conclusion that 'Heat is an expansive motion restrained, and striving to exert itself in the smaller particles.'

Bacon does not offer this result as a complete induction, but as what he calls a 'first vintage.' It is part of Bacon's doctrine of induction that were the three tables just described perfect and complete it would be possible to make a complete induction from their study. But Bacon realises the impossibility of framing such complete tables. He, therefore, remarking sagaciously that 'Truth emerges more readily from error than confusion,' suggests that a *first vintage* shall be drawn by making an attempt towards 'the Interpretation of Nature in the Affirmative,' from a study of these confessedly imperfect tables. Such an induction is necessarily incomplete, and to assist in arriving at a 'true and perfect induction,' Bacon draws up a list of what he terms *prerogative instances*. These are some twenty-seven in number and variable in their value. Again, we may best save explanation and illustrate their meaning and use by considering the twenty-sixth and fourteenth instances respectively—the *generally useful instances*, and the *instances of the cross*. Under the first-named heading Bacon discusses in general terms the possibility of obtaining information by controlling the external conditions which act upon natural bodies; in the instances of the cross, 'when the Understanding is . . . uncertain to which of two or more Natures the cause of the required Nature should be assigned . . . . the Instances of the Cross show that the Union of one Nature with the required Nature is firm and indissoluble, whilst that of the other is unsteady and separable; by which means . . . . the first is received as the cause, whilst the other is dismissed and rejected.'

It is evident that while deduction plays but a minor part in the Baconian scheme, his insistence on a reasoned inductive process marks a distinct advance. His method is by no means the infallible one for which he had hoped; his illustrations are on occasion puerile; he ignored and misinterpreted many of the scientific advances of his contemporaries; he was far from being a pioneer in his insistence on the value of observation and experiment. But he made a notable contribution to thought when he developed his early remark that the induction heretofore employed 'is improper, for it determines the Principles of Sciences by simple enumeration without adopting exclusions and resolutions or just separations of Nature'; and his whole philosophy is informed with such a dignified and close-packed thought, with such shrewd and weighty observations on human nature and affairs, as go far to explain his influence on his contemporaries and his successors.

He persistently rejected the Copernican theory; yet no one has more sagely classified the 'Idols or false Notions which have . . . . preoccupied the human understanding' than Bacon—the *Idols of the Tribe*, which 'are inherent in human Nature and the very Tribe or Race of man'; the *Idols of the Den*, which are those of each individual, inasmuch as 'everybody (in addition to the errors common to the Race of man), has his own individual Den or cavern which intercepts or corrupts the light of Nature;' the *Idols of the Market*, arising from the commerce and association of men with each other and engendered of the reason that 'men converse by means of language . . . . and there arises from a bad and unapt formation of words, a wonderful obstruction to the mind;' and finally, the *Idols of the Theatre*, 'which have crept into men's minds from the various dogmas of peculiar systems of Philosophy, and also from the perverted rules of Demonstration.'

This doctrine and its development should be followed in the pages of the *Novum Organum*. In Bacon's view and in that of some of his contemporaries, it forms a main buttress of his philosophy.

Little remains in the stones of London which we may directly associate with Bacon's personality. Born at York House in the Strand in 1561, he was entered at Gray's Inn in 1576. In 1600 he took a leading part in the trial of Essex at Westminster Hall. He was made Solicitor-General in 1607, Attorney-General in 1613, Lord Keeper of the Great Seal in 1617, Lord Chancellor and Baron Verulam in 1618, and in 1621 Viscount St. Albans. In that year he kept his sixtieth birthday at York House; in that year he was degraded and turned from the home 'where my father died and where I first breathed,' and where above all things he desired 'to yield my last breath if it so please God and the King will give me leave.'

Gray's Inn is still with us, and though the scaffold built for the trial of Essex in Westminster Hall and bearing 'a cloath of estate under which the Lord High Steward's grace . . . . did sitt as judge' has fulfilled its purpose and vanished, the venerable

Hall which witnessed the trial and Bacon's quiet but deadly interventions, still stands intact.

York House has all but gone; all that remains of it is Inigo Jones's Water Gate, now standing near the bottom of Villiers Street. Built as this was in 1626, it serves to remind us, not of Bacon's greatness, but of the greed of the royal favourite who forced York House from its owner in the hour of his adversity.

It was near Highgate in 1626 that Bacon made one of his few experiments—a pioneer experiment in refrigeration—and so met his death. Let his younger contemporary, Hobbes, tell the story: 'The cause of his Lordship's death was trying an experiment. As he was taking an air in a coach with Dr. Witherborne . . . . towards Highgate, snow lay on the ground, and it came into my Lord's thoughts, why flesh might not be preserved in snow, as in salt. They alighted out of the coach and went into a poor woman's house at the bottom of Highgate Hill and bought a hen and made the woman exenterate it, and then stuffed the body with snow, and my Lord did help to do it himself. The snow so chilled him that he immediately fell so extremely ill that he could not return to his lodgings (at Gray's Inn) but went to the Earl of Arundel's house at Highgate, where . . . . in two or three days he died.'

As we have already noted, the sixteenth century saw a remarkable growth of academies and learned societies. A spirit of inquiry and discussion was abroad and it is not surprising that Bacon's restless intellect should frame schemes such as are sketched in the *New Atlantis*, for the advancement of learning by collective research. But this development of

Bacon's mind, and the story of the growth of those scientific institutions which have played so great a part in the life of London are matters for subsequent chapters of this volume. Here we may more profitably survey the lives and work of some few of those individuals whose achievements are closely linked with the story of the advancement of science in London.

The dominating figure in the scientific life of London in the seventeenth century—favoured perhaps by force of circumstances—is that of Sir Christopher Wren. Quiet as was Wren's long life (1632-1723), he moved from task to task of the most varied kind so easily and steadily, with such masterly competence and assurance, that the mere volume of his accomplished work stands almost unequalled as the achievement of one man. Wren's precocity was amazing; at thirteen he wrote Latin verse of no small merit and had already achieved something in the design of astronomical instruments; at fourteen he entered Oxford as a fellow commoner of Wadham. Evelyn, during Wren's Oxford career, speaks of visiting 'that miracle of a youth, Mr. Christopher Wren, nephew of the Bishop of Ely,' and Evelyn was not a man given to the indiscriminate and uncritical use of epithets. Gresham professor of astronomy in London in 1657, Savilian professor at Oxford in 1661, it would seem that Wren's career was marked out on conventional academic lines, and the causes that turned him to the practice of architecture are somewhat obscure. Certainly his tastes were mathematical and mechanical, and were informed by a restrained, but none the less sincere sense of form and line, a sense which exhibits itself in the admirable manner in which he suits his many designs to the exigencies of the sites of his churches. Possibly a determining factor was his appointment in 1661 as assistant to Sir John Denham, the Surveyor General of Works for, up to that period, Wren's biographers discover no evidence of any special study of architecture. Two years later we find that the Bishop of Ely entrusted his nephew with the designs for a chapel for Pembroke College, his first architectural work of any importance. Wren's great opportunity came with the fire of London in 1666. He had already, in virtue of his official position, been called in to report on old St. Paul's, and in a document of great length, he points out with a sure hand, the fundamental and dangerous defects of the old building. The method of repair was long debated, but the fire finally settled the matter. Wren produced several designs for a new church, his own favourite being a design which in plan was a Greek cross with two domes, the larger over the crossing of the arms, the smaller behind the western portico. Externally the arms of the cross are joined by sweeping concave facades, and the design is one of great beauty. But a church with a circular choir and without a well-marked division into aisles and nave proved too much of an innovation for conservative minds, and Wren was asked to prepare another design. 'The Nightmare,' as it is known, depicts a single dome, the drum of which arises from what Archdeacon Sinclair calls a reversed pudding basin. The dome is surmounted, not by a lantern, but by a tall thin spire of diminishing stages, and the whole effect is ungraceful and even tawdry. Nevertheless the King states in choosing this design that he had 'particularly pitched on' it 'as well because we found it very artificial, proper, and useful as because it was so ordered that it might be built and finished by parts.' Fortunately Charles gave Wren 'liberty in the prosecution of his work to make some variations, rather ornamental than essential, as from time to time he should see proper, and to leave the whole to his management.' Probably no architect in history has ever interpreted the terms of such a permission so freely and so daringly as did Wren. The design was altered out of all recognition and the result is a Renaissance church which is unrivalled in Europe. The work of building dragged on amid countless vexations and hindrances. Wren was a young man when he started to clear the site of the ruins of old St. Paul's; he was all but an octogenarian when, in 1710, he ceremonially assisted at the laying of the last stone of the lantern of the cupola, and saw around him a cathedral, in essentials complete. And what a mass of work stretches over that span of years! The cathedral and its details were sufficient for the activities of one ordinary man; but Wren found time in his long and busy life to put forward, as Weld records, some fifty-three 'inventions and discoveries'; to forward the progress of the Royal Society and to occupy its presidential chair; and in London alone, independently of the cathedral, to plan and erect some thirty buildings of importance. Milman pictures the old man at the laying of the last stone looking down from the lofty heights of the lantern and seeing 'not the cathedral only, but a number of stately churches, which had risen at his command, and taken form and dignity from his genius and skill. On one side the picturesque steeple of St. Mary-le-Bow, on the other the exquisite tower of St. Bride's, with all its gracefully, gradually diminishing circles, not yet shorn of its full and finely proportional height. Beyond and on all sides, if more dimly seen, yet discernible to his partial eyesight ..... church after church as far as St. Dunstan's-in-the-East, perhaps even Greenwich may have been vaguely made out in the remote distance. And all this one man had been permitted to conceive and execute; a man not originally destined nor educated for an architect, but compelled as it were by the public necessities to assume the office, and so to fulfil it as to stand on a level with the most consummate masters of the art in Europe, and to take his stand on an eminence which his English successors almost despair of attaining.'

No Englishman of science has left more deeply the imprint of his personality on London than has Sir Christopher Wren; of no man of science do we possess more material memorials; and he who, with little time to command, would know and feel something of Wren's genius, must pick and choose. After St. Paul's, where he should not overlook those personal relics of Wren which are preserved in the library of the cathedral, he should by no means omit to see St. Mary-le-Bow, the interior of St. Stephen's Walbrook, St. Martin's Ludgate, St. Bride's Fleet Street, and perhaps as remarkable as any, St. Michael's Cornhill, the tower of which was built from Wren's designs in 1722, the ninetieth year of the architect's life.

Differing from Wren in almost everything save his insatiable industry, is John Hill (1716-1775). Botanist, apothecary, physician, hackwriter, actor, and playwright, with no little of the charlatan and some tincture of genius in his composition, Hill's is a curious figure. Apprenticed to a Westminster apothecary, he began to practise in St. Martin's Lane, and afterwards in Covent Garden. He was a sound systematist, and utilised his knowledge of plants by arranging the collections of others and himself making and arranging collections for sale. In 1746 he published a translation of Theophrastus on Gems, a publication which marks the beginning of a period of literary activity of the most varied kind, which lasted until his death.

Plays, novels, periodical literature and scientific works poured from his pen in rapid succession, and at one period of his career, according to Sir John Hawkins, 'though his character was never in such estimation with the booksellers as to entitle him to an extraordinary price for his writings, he has been known . . . . by . . . . . the labour of his own head and hand to have earned in one year the sum of fifteen hundred pounds.'

A combination of a facile pen, ability, and a quarrelsome disposition does not make for popularity, and Hill found himself continually engaged in acrimonious disputes. His plays are admittedly second-rate, but, bearing in mind the standard of the mid-eighteenth century stage in England, one realises that there is something more than mere criticism of Hill as a playwright behind Garrick's tart epigram

'For physic and farces, his equal there scarce is.
His farces are physic; his physic a farce is,'

or behind the thrust

'Thou essence of dock, and valerian and sage,
At once the disgrace and the pest of this age,
The worst that we wish thee, for all thy damn'd crimes
Is to take thy own physic, and read thy own rhymes.'

This last quatrain, it may be noted, produced the neat comment,

'Their wish must be in terms reversed,
To suit the Doctor's crimes;
For if he take his physic first,
He'll never read his rhymes.'

It is obvious that Hill was not a popular figure in Thespian circles in 1758.

Nor was his popularity any greater among men of science. The story goes that Hill had put himself forward as a candidate for membership of the Royal Society, and could not find the requisite number of Fellows prepared to sign his certificate. This again, if true, is a reflection of Hill's quarrelsome disposition, for his scientific work, in amount and character, is considerably higher than that of many of the more eminent Fellows of the period. Indeed, it is notorious that, under the presidency of Martin Folkes, the communications made to the society exhibited a distinct falling-off in quality. Whatever be the reason for Hill's non-election, he himself was not of the type that suffers silently, and his quarto *Review of the Works of the Royal Society of London* is a piece of pungent and not unamusing criticism. The Royal Society, in its early days, was a more easy-going and uncritical body that it has since become, and papers on 'A Boy who eat immoderately,' on 'An Easy Way of Taking a Vomit,' 'On the Transmutation of Water into Maggots,' and the classic 'Dissertation on Stittlebacks,' conceived in the manner of the late Mr. Pickwick, were fair game for Hill's satire. The book was not without practical value, for, as Weld remarks, 'shortly after its publication the Transactions possess a much higher scientific value.'

Hill made serious contributions to botanical science in the regions of Physiology, Anatomy, and Systematic Botany. His physiological work appears in a letter to Linnæus entitled *The Sleep of Plants and Causes of Motion in the Sensitive Plant explained*, and his experiments show a clear appreciation of the importance of proper control and comparison; Sachs notes that 'Hill had determined, in 1757, that the alternation of day and night was the cause of the movements connected with the sleep of plants, because he found that darkness artificially produced in the daytime made the plants assume the nocturnal position.'

His anatomical investigations are described in a volume entitled *The Construction of Timber*, but, in mass at least, his systematic work overshadows anything else which Hill has done. His *Vegetable System*, an immense work of some twenty-six folio volumes, his *General Natural History* in three volumes, and his folio *British Herbal*, are monuments of industry. In his *History of Plants* (1751), the second volume of his *General Natural History*, Hill first introduced, though critical of the method, the Linnæn system into England. His judgments on specific points were well in front of his age, and Mr. T. G. Hill remarks that it is not too much 'to say that time has justified his criticism; and many of his minor differences have been warranted.'

Hill died in Golden Square in 1775. His is a complex and arresting character, not easy to assess accurately; but he may fairly be said to have earned a place in the list of London's scientific worthies.

One of the most remarkable personalities that the eighteenth century produced is that of Henry Cavendish (1731-1810). Shy, cold, and reserved; completely indifferent to those springs of human ambition which guide the lives of ordinary mortals; a misogynist who ordered a special back staircase to be built because on one occasion he encountered a maid-servant on the stairs; a simple liver who daily dined on a leg of mutton, or, on those rare occasions when more than one or two guests graced his table, on two legs; taciturn as a trappist monk; and withal possessed of a mind more quantitative in its outlook than that of any man of science of his own or of any other age, Cavendish's queer figure is unique among London's men of science. The dominating passion of his mind was for measurement, and the order of his life in great things, as in small, shows how this passion overshadowed other things. If he drove out 'the exact distance he travelled was recorded on a way-wiser,[1] which instrument is, or should be, preserved in the King's College collection. He owned no wardrobe, and his one suit of clothes was renewed at strictly regulated intervals. Wherever he went a certain peg was sacred to his hat, and his boots must always stand ready for him at one particular spot, with his walking-stick standing in one particular boot. This same exact and unvarying habit of mind shows itself in all that he does. Whether the quantitative details of an experiment are important for the main issue or not, they are always faithfully and fully recorded. As his biographer points out, 'it would have been painful to him to have experimented otherwise'; and, while he had not the slightest regard for appearance in his instruments—common deal plays a great part in the construction of much of his apparatus—they are nevertheless designed with a regard to accuracy, and their capabilities are investigated in a manner far in advance of his time. Indeed, it is remarkable how little there is to alter in the results of his more important investigations. He determines the constant of gravitation and deduces therefrom the mean density of the earth, measuring the attraction between two metal spheres by means of the torsion balance suggested by Michell. His results show that the density of the earth is 5·45 times that of water, and scores of experiments and the passage of nearly a century and a half have but altered the figure to 5·53. He investigates the proportions of oxygen and nitrogen in the atmosphere, and arrives at numbers practically coincident with those of modern experimenters; his paper concludes with the almost prophetic observation that, if there is any part of the atmosphere which is neither oxygen nor nitrogen, it cannot be more than 1/120th part of the whole —almost exactly the proportion of argon present. He determines the composition of water. He is almost contemporaneous with Black in the doctrine of specific and latent heats. He remarks that 'on mixing hot and cold water . . . . the hot water should communicate as much heat to the cold water as it lost itself.' He then, apropos of the mixing of mercury and water, goes on to say that 'one would naturally imagine . . . . . that all bodies heat and cool each other when mixed together in proportion to their weights,' and describes experiments from which he concludes that 'water cools hot mercury as much as 30·42 times its weight of mercury can do, or the effect of water in cooling hot mercury is 30·42 times that of mercury.' He then proceeds to determine the latent heat of steam by means of what is now a well-known elementary laboratory experiment, that of finding the time it takes to raise a known quantity of water from, say, room temperature to boiling point, and comparing it with the time taken to boil away a measured quantity of the water. This, of course, assumes a constant source of heat, and Cavendish employed a compound spirit lamp possessing seven wicks. He finds, in one trial, using a Fahrenheit scale, that as much heat is lost 'by converting any quantity of water into steam as is sufficient to raise that quantity of water 982°;

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[1] Is it too late to make a plea for this word as a healthy substitute for cyclometer?

or in other words there are 982° of cold generated by converting water into steam.'

Some of Cavendish's most remarkable results are obtained in connection with his electrical researches, and remained unpublished and unknown for close on a century.[1] Passing with a bare mention his celebrated test of the inverse square law wherein he showed that the inverse power of the distance concerned must be $2 \pm \frac{1}{50}$, we note that he had devised clean-cut experiments for the comparison of capacities, and that he states, for example, that the ratio of the capacity of a sphere to that of a circle of the same diameter is 1·57 (the calculated ratio, of course, being $\pi : 2$ or $1{\cdot}5708 \cdots$). He proceeds to determine the capacities of plates of different substances 'coated in the manner of Leyden vials.' He finds on every occasion that the 'observed charge' is much greater than the 'computed charge,' that is, than the charge calculated from the dimensions of the plate condenser experimented on. He gives values for this ratio of about 4·47 for shellac, 3·5 for bees' wax, 7·8 for flint glass, 8·2 for plate glass, and 8·5 for crown glass. Thus, as Clerk Maxwell remarks, 'Cavendish had not only anticipated Faraday's discovery of the Specific Inductive Capacity of different substances, but had measured its numerical value in several substances.' But—most astonishing fact of all—he had, without any resources for the production or measurement of current such as were accessible to Ohm, anticipated by nearly fifty years the great discovery which is associated with Ohm's name. His process for the comparison of resistances is remarkable, and may be illustrated by a comparison which he made between the resistance of iron wire and of salt water. He charged two specified Leyden jars to a potential indicated by a straw electrometer and then arranged matters so that 'the shock of two jars had its choice whether it would pass 2,540 inches of nealed iron wire 12 feet of which weighed 14·2 grains, or through my body.' That is, Cavendish made a divided circuit between himself and the iron wire, discharged the jars through this circuit and utilised the shock felt in his wrists or elbows as a galvanometric indication.[1] He then proceeds: 'I then gave the shock its choice whether it would pass through my body or 5·1 in. of a saturated solution of sea salt contained in a glass tube 1 in. of which holds 9·12 grains of fresh water . . . . I found the shock to be just the same as before, and found, too, that increasing the length of the column of salt water not more than a quarter of an inch made a sensible difference to the strength of the shock.' From these experiments it is not difficult to show that the resistance of a saturated solution of sea-salt is $3{\cdot}554 \times 10^5$ times that of iron. Clerk Maxwell remarks that 'by Kohlrausch's experiments on salt solutions, combined with Matthiessen's on metals, the resistance of saturated solution of salt is 451,390 times that of annealed iron when both are at 18°C. The ratio of the resistances would agree with that given by Cavendish at a temperature of about 11°C. The coincidence with the best modern measurements is remarkable.'

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[1] In his lifetime he published two papers dealing with electrical subjects in the *Philosophical Transactions* for 1771 and 1776. The remainder of his electrical work remained hidden in obscurity until his papers were edited and published by Clerk Maxwell in 1879.

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[1] It is worth recording that this was not the only occasion on which Cavendish made use of the intensity of his subjective perceptions for the purpose of physical measurement. In 1766 he employed what Wilson calls an Acoustic Endiometer, making a rough estimate of the composition of the atmosphere by noting the loudness of the report observed when a specimen of air was mixed with hydrogen and exploded.

The 'low white building on Clapham Common opposite the fifth milestone from Cornhill,' for many years the house of Cavendish, disappeared some years ago, but a tablet on 11 Bedford Square commemorates his residence there, and those who walk along Dean Street, Soho, may care to remember that here Cavendish had housed a large reference library, access to which was open to any serious research worker. To this library he would himself repair, giving vouchers like any ordinary user of the library for the books which he took out.

Much of Cavendish's coldness must be put down to his inveterate shyness and to his absorption in his pursuits. If his attention could be captured he could be, on occasion, more generous than the circumstances demanded. Mr. W. H. Pepys, who knew Cavendish personally, tells us, apropos of Cavendish's London library, that it was catalogued for him by a gentleman in reduced circumstances who, the task accomplished, passed from the knowledge of Cavendish. At the Royal Society Club this gentleman's name came up in conversation, "upon which Mr. Cavendish said, 'Ah, poor fellow; how does he do? how does he get on?' 'I fear very indifferently.' . . . . . 'I am sorry for it' said Mr. Cavendish. 'We had hopes you would have done something for him, sir.' 'Me, me, me, what could I do?' 'A little annuity for his life; he is not in the best of health.' 'Well, well, well, a check for ten thousand pounds, would that do?' 'Oh, sir, more than sufficient, more than sufficient.' "

Cavendish's apparatus was inherited by Lord George Cavendish. It has since been dispersed, but one or two specimens are to be seen at the Royal Institution. It is much to be desired that a catalogue should be drawn up, as complete as may be, of the instruments still extant that are known to have been the personal property of this remarkable man.

Temperamentally very different from Cavendish, but gifted with the same passion for accuracy in detail, was William Hyde Wollaston (1766-1828), whose connection with London and with the Royal Society is very close. He served the latter body for many years as secretary, and during the half year's interval between the death of Sir Joseph Banks in 1820 and the election of Sir Humphry Davy, filled the presidential chair. Wollaston was a born experimenter, and in the science of chemistry developed what might almost be called a micro-technique to a standard hitherto unheard of. It was his special pleasure to devise ways and means of dealing with small quantities—his method of drawing fine wire is an example—and he had remarkable skill in the manipulation and in the analysis of substances obtainable only in the smallest quantities. Dr. Paris relates a story of a foreign savant who called on Wollaston and asked to see his laboratory. " 'Certainly,' replied Wollaston, and immediately produced a small tray containing some glass tubes, a blowpipe, two or three watch glasses, a slip of platinum, and some test tubes."

One interesting little relic of Wollaston and of another writer whose connection with London is intimate—Mrs. Mary Somerville (1780-1872)—may be seen in the Science Museum, to which it has recently been presented by a member of Mrs. Somerville's family. The story is best told in Mrs. Somerville's own words.[1] 'One bright morning Dr. Wollaston came to pay us a visit in Hanover Square, saying, "I have discovered seven dark lines crossing the solar spectrum which I wish to show you;" then closing the window shutters so as to leave only a narrow line of light, he put a small glass prism in my hand, telling me how to hold it. I saw them distinctly. I was among the first, if not the very first, to whom he showed these lines, which were the origin of the most wonderful series of cosmical discoveries and have proved that many of the substances of our globe are also constituents of the sun, the stars, and even of the nebulæ. Dr. Wollaston gave me the little prism, which is doubly valuable, being of glass manufactured at Munich by Fraunhofer, whose table of dark lines has now become the standard of comparison in that marvellous science, the work of many illustrious men, brought to perfection by Bunsen and Kirchhoff.'

The 'little prism' with its many memories is now safely housed in the Science Museum, and the house at which the incident occurred—12 Hanover Square—may still be seen and identified by a plaque recording Mrs. Somerville's residence there. One or two passing remarks may be added concerning the details of her recollections. It is not to be expected that, writing as she did many years after the event, she should exactly remember all the details of the incident. The facts are that Wollaston announced his discovery of the dark lines in a paper presented to the Royal Society in 1802. Incidentally it may be remarked that he quite misinterpreted their character, and regarded them as lines serving to mark out the solar spectrum into definite *regions;* and that Fraunhofer rediscovered them and studied them in detail in 1815. The Somervilles settled in Hanover Square in 1816, and the incident which we have chronicled must have happened subsequently to this date and probably in 1818 or 1819. It is hardly likely, then, that the prism is the one with which Wollaston made his early investigation, nor did Mrs. Somerville see the lines soon after their discovery by Wollaston. But the prism loses no interest on that account, and it is a pleasure to know that it has taken its place in our national museum with other scientific treasures possessing unique personal associations.

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[1] *Memoirs of Mary Somerville*, p. 133.

The list of eminent names associated with science in London could be extended almost indefinitely. Newton dwelt in St. Martin's Street and in Jermyn Street; Thomas Young, the practising physician and professor of physics at the Royal Institution, lived in Welbeck Street; Ronalds in Kelmscott House, Hammersmith[1], where may be seen a tablet recording the fact that in 1816 an electric telegraph, some eight miles long, was constructed by Francis

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[1] Where William Morris died in 1896.

Ronalds; and hard by Manchester Street lived that eccentric and versatile mathematician, Charles Babbage, who, critical of the fluxional notation, helped to form a society to inculcate 'the principles of pure D-ism in opposition to the Dot-age of the University,' and whose difference engine may be seen in the Science Museum. Babbage has a special interest for members of the British Association. It was he who, staying in Berlin in the autumn of 1828, learnt that 'Dr. Oken had proposed and organised an annual congress of German naturalists meeting in each successive year in some great town.' And it was he who wrote an account of that meeting to Brewster, who published the description of it in the *Edinburgh Journal of Science* for 1829. Babbage asserts that this was the first communication to the English public of the existence of the German Society,[1] and doubtless the article played a not unimportant part in the shaping of Brewster's opinions.

The list could, with increasing interest, be brought closer to our own time. Crookes, Lockyer, Huggins . . . . . . these are names intimately associated with London and with the Association. But the few names which we have discussed have brought us to the time of the founding of the Association—a period at which our account of some of the founders of science in London may fitly close, leaving the details of the development of London's great institutions to later chapters in this volume.

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[1] *Passages from the Life of a Philosopher*, p. 432.

CHAPTER II

THE LEARNED SOCIETIES—THE ROYAL SOCIETY

AT the time of the foundation of the Royal Society (1660), oldest and most eminent of those scientific societies which fall for consideration in this and the following chapter, there was hardly more of specialisation in science than had existed in the age of Aristotle. At the beginning of the nineteenth century it was still possible for a gifted cultivator of science to hold (for example) a professorial chair in a variety of subjects which to-day would be inconceivable. Before the year 1818 only six of the societies to be noticed in Chapter III had been founded—the Society of Antiquaries, the Royal Society of Arts, the Linnean Society, the Royal Institution, and the Geological and Royal Horticultural Societies, together with the senior medical societies noticed at the close of Chapter VIII. But the period following those of Newton and Laplace, James Hutton, Lamarck, and a few other pioneers of the advancement of science, was one of powerful development of scientific investigation and of great activity in the organisation of science through societies. To the years 1818-41 belongs the foundation of the Institution of Civil Engineers, and the Astronomical, Zoological, Geographical, Entomological, Statistical, Agricultural, Botanical, and Chemical societies, among others, as will appear in the following chapter. To the same period belongs the foundation of the British Association (1831), which finds no further place in these pages, save in so far as it has had concern with certain of the institutions mentioned elsewhere. For though its headquarters are in London, its statutes disclaim 'invasion of the ground occupied by other institutions,' and therefore its annual meetings, until the centenary meeting of 1931, have never been held in London.[1]

Though the societies dealt with in the following chapter include a few more exclusively technical or concerned with applied science, the foundation of which fall within this same period, the majority are societies for 'pure' science. Later, there is a tendency for the fuller development of technical societies than those of the other class—a very natural process. There is also observable a distinct impetus toward the foundation of societies in the period of the great exhibitions of 1851 and 1862. These points are noticed here because it has appeared undesirable to refer to all the societies in one chronological list; instead, an attempt has been made to classify them. The method adopted is admittedly arbitrary, especially considering the perceptible tendency in modern times toward the disappearance of barriers between the various departments of science. It is arguable, indeed, that the disappearance of barriers between some of the societies themselves—those founded during the earlier part of the period of specialisation—may in the future be no evil for the organisation of science. The selection of societies for notice in this volume may well appear to be arbitrary too; it is not deliberately so; but the line between societies which may be called scientific and those which definitely cannot is frankly impossible to draw. Thus far apology, save for an expression of regret that the consideration of space has prohibited the use of much material of great interest which many of the societies have generously offered. The full history of the organisation of science through societies is a tale not yet told.

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[1] The history of the Association is dealt with in the volume uniform with this, *The British Association: A Retrospect*, second edition, 1931.

THE ROYAL SOCIETY

By F. A. TOWLE

THE Royal Society of London for Improving Natural Knowledge originated in the meetings of a group of men who had taken up experimental investigation either as the pursuit of their lives or of their leisure. They termed themselves a 'philosophical college,' following, no doubt, the ideas put forward in Bacon's posthumous *New Atlantis*. It is recorded that in 1646 'they mett at the Bull-head Taverne in Cheapside till it grew to big for a clubb, and so they came to Gresham College[1] parlour,' their object being 'no more than only the satisfaction of breathing a freer air, and of conversing in quiet tones with one another, without being ingag'd in the passions and madness of that dismal age.' They continued to meet once or twice a week in term time until 1658, when their place of meeting was made a quarter for soldiers; but in 1660, the political situation having changed, the meetings at Gresham College were revived and the members formed themselves into a regular society. Charles II expressed great satisfaction that such an institution had originated during his reign and promised to support it with his influence. Accordingly, a Royal Charter was granted in 1662, and, as a further mark of Royal favour, a mace 'of the same fashion and bigness as those carried before His Majesty to be borne before our President on Meeting days,' was presented. This mace is still laid before the President at all meetings of the society and of the Council. After the Fire of London the society was again obliged to leave Gresham College, this time to make room for members of the Exchange, whose building had been destroyed, and from 1666 to 1673 rooms were placed at its disposal by Henry Howard, afterwards Duke of Norfolk, in Arundel House on the site now occupied by Arundel and Norfolk streets. In 1673 the society again moved to Gresham College, remaining there until 1710, when a house in Crane Court, Fleet Street, was purchased; and these premises continued to be the society's abode for seventy years. In 1780 rooms at Somerset House were placed at its disposal by the Government; in 1857 the society moved to Burlington House, and in 1873 took up its present quarters in the east wing. In 1669 Charles II made a gift to the society of buildings and 30 acres of land in Chelsea known as Chelsea College. This property was never occupied by the society and was, at his request, surrendered to the King in 1682, who converted it into an asylum (the Chelsea Royal Hospital) for old and disabled soldiers.

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[1] See Chap. IV, p. 146.

The men of science properly so called who appear in the first list of fellows were barely one-fifth of the whole number, but they included some whose names are held in remembrance wherever the history of science is known. Others were mostly 'gentlemen, free and unconfin'd, who by the freedom of their education, the plenty of their estates, and the usual generosity of the noble bloud, may be well supposed to be most averse from sordid considerations.' The first President was Viscount Brouncker; other presidents in the seventeenth century were Sir Christopher Wren and Samuel Pepys. Another diarist, John Evelyn, was appointed Secretary in 1672. During the early years of the society the proceedings at an ordinary meeting differed a good deal from the present practice. Instead of the reading of papers, attention was given to experiments, which were performed by the fellows themselves, or by officials appointed by them, and the society was spoken of as one 'for the Improving of Natural Knowledge by Experiments.' During the Great Plague the meetings were suspended for some months and were again interrupted by the Great Fire; but with these exceptions there has been an almost unbroken record of weekly meetings during session time for two hundred and sixty-eight years. In the early days special committees were appointed to carry out investigations and to make enquiries into particular questions, as is the practice now, and permanent committees were instituted to take charge of some special branch of knowledge. In 1664 eight such committees were in existence, namely: (1) mechanical (to consider of and to improve all mechanical inventions); (2) astronomical and optical; (3) anatomical; (4) chymical; (5) georgical; (6) for history of trades; (7) for collecting all the phaenomena of nature hitherto observed; (8) for correspondence. At the present moment there are sixteen 'standing and occasional,' and eight 'sectional' committees, in addition to special boards for allotment of the Government grant. Among the society's most treasured possessions are a book containing the signatures of all the fellows who have been 'admitted' into the society; and the original reflecting telescope of Newton, made with his own hands in 1671.

At one time there was a collection of what were called 'rarities,' and for nearly a hundred years before the founding of the British Museum the Royal Society's Repository was the centre to which specimens of every kind, objects of natural and antiquarian interest, and various sorts of curiosities, natural and artificial, were sent from all parts of the world. In less than twenty years the collection had increased so much that a folio volume of about 500 pages was published as a catalogue and description of its contents. This catalogue forms an interesting compendium from which the state of knowledge in regard to natural history at that time (1681) may be inferred. The collection was long ago dispersed among the specimens in the British Museum and elsewhere[1].

The library consists of about 100,000 volumes, and contains many books and manuscripts of historic interest, including the original of Newton's *Principia*, and collections of MS. communications to the society by Leeuwenhoek, Malpighi, and others. Since 1660 the records of the doings of the society at its meetings have been kept in a manuscript book, known as the Journal Book. The *Philosophical Transactions* appeared in March 1664-5, and from that day this remarkable series, which contains a large part of the history of science in this country from 1664 to the middle of the nineteenth century, has been continued. The *Proceedings* were first published in 1832, as abstracts of the communications published in the *Philosophical Transactions*, but have now, for many years, formed two important periodicals for the publication of complete papers of a shorter type than those appearing in the *Philosophical Transactions*.

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[1] See, further, Chap. IX, p. 274.

From its foundation the Royal Society has acted in an advisory capacity to His Majesty's Government on all scientific questions, but the creation in recent years of Government organisations for the support of research in certain directions has relieved it of some of these duties. It is not permissible to say much of the work done by the society during the Great War. Committees were appointed at the request of the Government 'to which questions could be referred for investigation and report.' The Food Committee alone furnished more than seventy reports, many of which were published, but the reports of other committees can be found only in the archives of the Government departments concerned. The society has also taken a very active part in promoting expeditions for scientific and geographical exploration and magnetic and astronomical observations—Arctic expeditions under Parry, Ross, and Franklin; Antarctic expeditions under Cook, Ross, and Scott; observations of the transits of Venus, and numerous solar eclipse expeditions. Of recent years commissions have been sent by the society to tropical parts of the Empire to investigate diseases peculiar to those climates.

Although the funds which the society is able to use for its general purposes are small, it has received, of recent years, through the generosity of benefactors, funds to be held in trust for special purposes now amounting to about £600,000. From a bequest in 1897 the society was able to found its first studentship; now (1931) there are in existence six research professorships and nine research fellowships and research studentships. Two lectures, the Croonian and Bakerian, are delivered annually. Dr. Croone, one of the original fellows, left at his death a scheme for a lectureship which he intended to found, but made no provision for carrying out his wishes. His widow, however, remedied the omission in her will, bequeathing property to the society 'for the support of a lecture and illustrative experiment for the advancement of Natural Knowledge on local motion,' or on such other subjects as the President and Council might select. The first lecture was delivered in 1738. The Bakerian lecture originated in 1775 through a bequest of Henry Baker, F.R.S., for an oration or discourse by some one of the fellows on such part of natural history or experimental philosophy as the President and Council shall please to appoint. In 1928 the contributors to a fund to perpetuate the memory of Sir David

Ferrier and his pioneer work on the functions of the brain, handed over to the society £1,000 for the institution of a lecture to be given triennially 'on a subject related to the advancement of natural knowledge on the structure and function of the nervous system.' The first lecture was given in 1929 by Sir Charles Sherrington. The following medals are awarded by the society, dates of their foundation being given in brackets: The Copley (1736); The Rumford (1796); two Royal Medals (founded by George IV); the Davy (1869); the Darwin (1890); the Buchanan (1890); the Sylvester (1897), and the Hughes (1900). The society administers annual Government grants of £6,000 for scientific investigations, and £2,500 in aid of publication of scientific papers. It also administers a small private fund to aid such scientific men or their families as may require assistance, the intention being to 'afford prompt relief of the immediate wants of those upon whom sudden affliction has fallen' rather than the grant of annuities. In 1847 a new statute limited the number of Fellows annually elected to fifteen, and this number has remained unchanged till the present year (1931), when it was increased to seventeen. The society has also not more than sixty Foreign Members elected at less regular intervals. At the end of 1930 there were 449 Fellows and 44 Foreign Members on the register. On the roll of presidents, in addition to those already mentioned, appear the names of Sir Isaac Newton, Sir Hans Sloane, Sir Joseph Banks, Sir Humphry Davy, Sir Joseph Hooker, Professor Huxley, Lord Kelvin, Lord Lister, Sir William Huggins, Lord Rayleigh, Sir Archibald Geikie, Sir

William Crookes, Sir Joseph Thomson, Sir Charles Sherrington, and Lord Rutherford. Sir Frederick Hopkins was elected President in 1930. The officers and other members of the Council are elected annually, but it has been a practice of long standing for the President to serve for not more than five years, the Treasurer and Secretaries for ten, and the Foreign Secretary for four. It was not always so in the past, Sir Isaac Newton having served as president for twenty-three years, and Sir Joseph Banks for forty-one. The Anniversary Meeting is held on St. Andrew's Day. Evelyn records in his *Diary* (November 30, 1663): 'It being St. Andrew's Day, who was our Patron, each fellow wore a St. Andrew's Cross of ribbon on the crown of his hat.' Pepys says 'I had his cross set on my hat, as the rest had, and cost me 2s.'

This is but a brief account of a great and honourable society, which commands the respect of the scientific world. 'Although the vast development of physical and biological research during the last century has led to the creation of many other societies, each devoted more particularly to the cultivation of its own branch of research, the Royal Society remains at their head as the one great institution in this country which embraces in its purview the whole wide realm of nature, and elects into its ranks the most accomplished representatives of every department of science.'

CHAPTER III

THE LEARNED SOCIETIES
(continued)

SOCIETIES CONCERNED WITH SCIENCE GENERALLY

IN the words of the late Sir H. Trueman Wood, secretary to the Royal Society of Arts, the Society is one of the three oldest of the learned and scientific societies in England, for when it was founded in 1754 only the Royal Society and the Society of Antiquaries were in existence. As it had a large field to itself it was comprehensive in the scope of its work. For a long time it alone filled the place which is now occupied by the many societies which have since been founded for the promotion of special branches of science, industry, and art. It was—as indeed it still is—at once scientific, technical, industrial, commercial, and artistic. Before the foundation of the Royal Academy it held exhibitions of pictures, and assisted in the education of art students by prizes and examinations. Until the Royal Agricultural Society was established, it was the principal institution in the country for the promotion of agriculture and the application to agriculture of scientific principles. It anticipated the Institution of Civil Engineers, and the other engineering institutions, in the encouragement of civil and mechanical engineering. It encouraged chemical research, and the application of chemistry to industry, before the Chemical Society and the other chemical institutions existed. And it promoted arts and industries in the Colonies more than a century before the Royal Colonial Institute or the Imperial Institute.

The improvement of agriculture was one of the first objects of the society, and the first volumes of its *Transactions* are largely devoted to this subject. It was especially successful in its efforts to provide afforestation. During the first half century of its existence large premiums were awarded for new and valuable inventions. But as time went on it was felt that publicity for such discoveries would be better secured by the delivery of descriptive lectures than by the award of prizes, and since 1842 meetings have been held for the reading of such papers. Special sections exist for subjects relating to India and the dominions and colonies. Other learned societies have originated more or less directly from the Royal Society of Arts, but it remains as an unspecialised society, affording opportunity of discussion of any subject falling within its wide scope, though devoting itself principally to the application of science and art to practical uses. The Prince Consort, president from 1843 until his death (1861), gave valuable help to the society's work in this direction. His long association with the society was commemorated by the foundation of the Albert Medal. The society has been closely identified with the foundation of international exhibitions, and with the development of local examinations. It aroused early interest in technical education, and fostered the establishment of the City and Guilds Institute, which carries on extensively the technical examinations begun by the society. Other public activities begun or encouraged by the society include improvements in the Patent Law, the establishment of the parcels post, the introduction of inexpensive scientific apparatus, the marking by tablets of the houses of distinguished men, and the founding of the music training school which afterwards became the Royal College of Music. Among the society's activities at the present time, besides the meetings for reading papers and the publication of a weekly journal, are the holding of commercial examinations and of an annual competition for industrial designs, and work for the preservation of ancient cottages. The society has occupied premises in John Street, Adelphi, since 1774. It was incorporated by Royal Charter in 1847.

The Royal Institution differs from most other scientific societies in covering a wider field and making its appeal to a wider membership. Its chief activities consist, firstly, in the delivery of lectures on some new discovery or development of science or some fresh aspect of a social, literary or scientific subject. These are given weekly during the session on Friday evenings; there are also afternoon lectures for detailed description and experimental scientific work, and a course of Christmas lectures for children. The second side of the work of the institution consists in the researches, many of which have become historic, carried on in its laboratories, and financed mainly by members' subscriptions and by donations. Many of the fundamental discoveries in chemistry and physics on which the fabric of industrial expansion has arisen, were worked out here by such men as Thomas Young, Faraday, Davy, Tyndall, Rayleigh, J. J. Thomson, Rutherford, and Bragg; and much of the apparatus used by eminent men who worked in the Institution is preserved there. The institution was founded in 1799 by Benjamin Thompson, Count Rumford, at a meeting at Sir Joseph Banks' house in Soho, for 'diffusing the knowledge and facilitating the general introduction of useful mechanical inventions and improvements, and for teaching by courses of philosophical lectures the application of science to the common purposes of life.' It received a Royal Charter in the following year. Whilst owing its inception entirely to Count Rumford, the continuance and prosperity of the institution was due to the devotion first of Sir Humphry Davy and then of Michael Faraday. For fifty years after 1815 the life of Faraday and the history of the Royal Institution were inseparable. The institution has been housed in Albemarle Street since its foundation, when considerable alterations were made to the then existent building, including the building of the historic lecture room. In 1930 a further large rebuilding scheme was undertaken. In 1896 the Davy Faraday Research laboratory was founded and endowed for original research by means of a bequest by Dr. Ludwig Mond. It is housed in an adjoining building in Albemarle Street; it is not a teaching institution but is used by trained research workers under the direction of the resident professor. The Royal Institution possesses a large library which includes collections of manuscripts, letters, and papers of the distinguished men who have been connected with it.

The Royal Microscopical Society was initiated by a small band of scientific men who met in 1839 at the house of the brothers Quekett in Well Close Square, near Tower Hill, where at that time several enthusiastic microscopists had their homes. Two of them, N. B. Ward (who invented the Wardian glass case for transplanting flowers), and Dr. J. S. Bowerbank (best known for his work on sponges), were active in the formation of the society, as was Edwin Quekett, who was botany lecturer at the London Hospital. His brother, John Quekett, later Hunterian professor at the Royal College of Surgeons, was secretary of the society for nineteen years. Among others present at this preliminary meeting was Joseph Jackson Lister, father of Lord Lister; at the public foundation of the society at the rooms Horticultural Society in Regent Street, Richard Owen was elected president. Its aims were to promote the study of microscopical and biological science and to improve the construction of the microscope by discussion and publication of discoveries and investigations, and the development of microscopy as a science, not only in the design and construction of the instrument, but also in its many applications to science and industry, is due to the influence of the society, whose standards are universally recognised and adopted by scientific instrument makers. For ten years, after a short period of connection with the *Microscopic Journal*, the society issued its own transactions. From 1852 till 1868 they were published in the new *Quarterly Journal of Microscopical Science*, under a financial arrangement which finally led to difficulties, and after that in the *Monthly Microscopical Journal.* Since 1878 the society has published its own quarterly journal, which, in addition to the proceedings of the society, contains abstracts of the world's literature on microscopy. The society was housed in the rooms of the Horticultural Society (with the exception of one year with the Chemical Society) till 1856; then at King's College till 1890, and then for forty years in rooms in Hanover Square, till a move was made to its present quarters in the house of the British Medical Association in Tavistock Square. The society possesses the best library of its kind in the world, and an unique collection of historical instruments. It was incorporated by Royal Charter in 1866.

The British Science Guild was founded in 1905 by the late Sir Norman Lockyer, K.C.B., F.R.S., with the object of promoting the application of scientific methods and results to social problems and public affairs. Soon after its foundation, committees were constituted to consider various matters which at that date were held to be of importance; and this procedure has been continued to the present time. Many distinguished representatives of science, industry, and education have served on these committees, and a large number of very diverse questions have been investigated. In the majority of cases reports on these matters have been framed and placed in the hands of Ministers in charge of the appropriate Government departments, the reports being widely circulated subsequently.

In 1925 the annual Norman Lockyer Lecture was established. The lecture is given in London, and its general aim is to illustrate the influence of science upon human progress. In 1929 the annual Alexander Pedler Lecture was founded. This lecture is given in the provinces and deals with some subject of scientific interest.

In 1921 the guild published the first edition of a *Catalogue of British Scientific and Technical Books*. This contained the titles of 6,627 British books actually obtainable at the publishers at the date of going to press, and subsequently two further editions were issued: the latest (1930) contains 13,915 titles. The catalogue is representative of recent scientific literature so far as text-books and works of reference in the fields of science and technology are concerned, and is limited to books issued by British firms.

There are two societies whose relations with science must not be overlooked here—the Royal Empire Society, and the Aristotelian Society.

The Royal Empire Society was founded as the Colonial Society in 1868, at a public meeting presided over by Viscount Bury. Its object was to combat the Cobdenite School which held that the colonies were a drag on the mother country, and that both would be better off apart. The society was pledged to be definitely non-party in character, its sole purpose being to educate the public to an understanding of Empire affairs and the advantages of Empire unity. W. E. Gladstone was present at the inaugural meeting.

It has been said that the society changed the public opinion of England. Certainly about the time it came into existence a marked change began to appear in the general attitude towards the colonies. In its second year it was accorded the privilege of styling itself Royal, but this involved a change of name, as the initials R.C.S. were those of the Royal College of Surgeons. It therefore became the Royal Colonial Institute, under which name it was known until the year of its diamond jubilee (1928) when it was again changed, becoming the Royal Empire Society in order to bring its designation into conformity with the new status of the Dominions. Its Charter was granted in 1882.

The membership has increased, with intervals when it seemed to have reached its maximum, until to-day its total is some 19,000, and its headquarters activities are supplemented by those of important branches at home and overseas. Its transactions were published as *Proceedings* from 1868 to 1910, and as a Journal, *United Empire*, since that date, and the society possesses a unique library of 210,000 volumes bearing on every phase of imperial history, development and resources. The society has provided a platform from which a long list of distinguished Empire statesmen and students have diffused knowledge of the British Empire, and it has always been peculiarly fortunate in the keen interest taken in its work by its presidents, of whom there have been six: Viscount Bury (1868-71), the Duke of Manchester (1871-78), the Prince of Wales—King Edward VII (1878-1901), the Prince of Wales—King George V (1901-10), the Duke of Connaught (1910-12), Earl Grey (1912-17), and again the Duke of Connaught since 1917. The society files at its headquarters building some 1,200 magazines and weekly, daily, and other newspapers published throughout the British Empire, and welcomes consultation of the files, which are kept up-to-date.

The Aristotelian Society has as its ideal, in the words of the late Prof. H. Wildon Carr, 'the study of philosophy not as an academical subject but as the story of human thinking.' Its objects are thus expressed: 'the systematic study of philosophy; first, as to its historical development; second, as to its methods and problems. Its name justifies its notice in this place; so also does the name of its originator—Alfred Senier, at the time of the society's foundation an analytical chemist in London; afterwards professor of chemistry in the University of Galway. The meeting at which the society was constituted took place in 1880, and subsequently Shadworth Hodgson became the first president. *Proceedings* have been published from an early stage of the society's activity, with an interval from 1897 to 1900, when the society's original papers were published in the journal, *Mind.*

PHYSICAL AND MATHEMATICAL SOCIETIES

The Royal Astronomical Society owed its inception to Sir John Herschel, with other astronomers, notably Francis Baily (1774-1844), who was the central figure of the society's early years. Sir John Herschel's father, Sir William Herschel, was the first president, when the society was founded at a dinner at the Freemasons Tavern, Lincoln's Inn

Fields, in 1820. Regulations for deciding by ballot of the Council as to whether or not papers read to the society should be printed in the *Memoirs* or not were adopted in 1821, and have remained in force ever since. The publication of *Monthly Notices* (largely abstracts of papers) was begun in 1827, and gradually took the place of the *Memoirs* as the chief publication of the society. Gold and silver medals have been awarded for astronomical work since 1824, and a Royal Charter was granted in 1831. One of the earliest tasks of the society was the reform of the *Nautical Almanac*, a work which has been continued to the present time. The society moved into its first permanent home, which was occupied for forty years, in Somerset House in 1835. In 1874, after the reconstruction of Burlington House, the society moved to quarters in the west wing there. Its early publications bear witness to the rapid rise of astronomy in Great Britain after a long period of stagnation, and is specially connected as regards astronomy of precision, with the names of Airy and Herschel. The steady growth of the class of amateur astronomers and the fresh spirit shown in the public observatories, testified to the usefulness of the new society. Among the numerous special undertakings of later years may be mentioned the work for the furtherance of geodetic observations, the meetings for the encouragement of the study of geophysics, the publication of *Geophysical Supplements* to the *Monthly Notices*, and the joint committee with the Royal Society for observing total eclipses. After the subject had been discussed at intervals over a long period, women were admitted as members after 1915.

The History of the Royal Astronomical Society, 1820-1920, edited by J. L. E. Dryer and H. H. Turner, was published in 1923.

The first public suggestion for the formation of the British Astronomical Association came from Mr. W. H. S. Monck, who had been an active member of the Liverpool Astronomical Society, resident in Dublin, and in a letter to the *English Mechanic* of July 18, 1890, proposed the formation of a similar society but with some differences in its methods of operation. The suggestion was taken up warmly by Mr. Edward Walter Maunder, a member of the staff of the Royal Observatory, Greenwich, who, as editor of the *Observatory Magazine* some years previously, had acquired a considerable circle of acquaintance among amateur astronomers, and it is to him almost entirely that the formation and continuance of the British Astronomical Association is due, though he had the support of and encouragement of several well-known workers in the science, one, though not then to be placed in that category, whose co-operation was of the greatest value, being Mr. William Henry Maw, editor of *Engineering*, who took the chair at the inaugural meeting in 1890, and was treasurer of the Association for the first twenty-three years of its existence.

The British Astronomical Association was founded for the encouragement of amateurs to carry out work of real astronomical value, and since it was realised that astronomical amateurs may be of any age, of either sex, rich or poor, or of any country, women were admitted to membership from the beginning, the subscription was made small, and a name was chosen that should be comprehensive. The word 'amateur' was omitted advisedly, for it was hoped, as has proved to be the case, that the support of astronomers holding official positions would not be withheld.

The objects of the Association are: (1) the association of observers, especially the possessors of small telescopes, for mutual help and their organisation in the work of astronomical observation; (2) the circulation of current astronomical information; and (3) the encouragement of a popular interest in astronomy.

With the object of organising and combining, observations sections were formed (adopting a feature of the Liverpool Astronomical Society), each devoted to a particular object or objects of the heavens, in which members enrol themselves according to their predilection and contribute their observations to be collected and prepared for publication by one of them who is nominated as director. The Memoirs of the Jupiter Section, now twenty-five in number, form an unique history of the surface features of that planet year by year; and the last published report of the Variable Star Section, another outstanding example, exhibits the work of forty-eight observers in all parts of the world, India, South Africa, Canada, and Australia, as well as European countries, on fifty-one stars during the years 1920-1924.

The Association was incorporated in 1911. It possesses a library covering all branches of astronomy, a large collection of lantern slides available for the use of members, and a collection of instruments acquired by gift that are issued on loan to members. The monthly meetings are held at Sion College, Victoria Embankment.

The Royal Meteorological Society, originally the British Meteorological Society, was founded in 1850 through the efforts of a body of enthusiastic pioneers interested in meteorology. The first informal meeting of the society was held in the library of Hartwell House, Aylesbury, the residence of Dr. John Lee, F.R.S. S. C. Whitbread, F.R.S., was its first president, and Dr. James Glaisher, F.R.S., its first secretary. The society was incorporated in 1866 and given the title of Royal in 1883; in 1921 the Scottish Meteorological Society was incorporated with it. It exists for the promotion of the science of meteorology, for which purpose it holds meetings, publishes a *Quarterly Journal and Memoirs*, and arranges lectures and exhibitions; it has a valuable library. In the early years of the society its most important field of activity was the establishment of climatic observation stations; later the work of providing official records of climate was undertaken by the Meteorological Office. In 1901 the society, in conjunction with the Meteorological Office, inaugurated the systematic investigation of the upper air in this country and established a station for that purpose in charge of the late Mr. W. H. Dines, F.R.S. A number of other investigations have been made by the society with such subjects as thunderstorms and wind force, and a rainfall atlas of the British Isles was published in connection with the Meteorological Office.

The Physical Society owes its existence almost entirely to a circular letter sent out in the autumn of 1873, on his own responsibility,by Frederick Guthrie (1833-1886), the scientific writer, poet, and sometime professor in the Normal School of Science at South Kensington. In 1914 the Council of the Society inaugurated a series of lectures, known by his name, as a token of appreciation and to keep alive his scientific reputation.

It becomes yearly more difficult to keep in touch with the growing volume of physical research; but by means of its publications, its meetings and lectures, and its annual exhibition, the Physical Society does much to keep its members acquainted with modern developments in all branches of physics. Fellowship of the society is open to all who are interested in physics, and persons under twenty-two years of age may become student members. The society issues *Proceedings*, published five times annually, containing original papers, lectures by specialists, reports of discussions and of demonstrations, and reviews. *Science Abstracts A*, published monthly, in association with the Institution of Electrical Engineers, summarises practically the whole field of contemporary physical research. *Reports* are critical monographs on special subjects, prepared by experts and issued from time to time by the society. The *Bulletin* and the *Agenda Paper*, issued fortnightly during the session, keep members informed of the discussions on papers read at the previous meetings, and of the agenda of future meetings and business of the society generally; and *Science Abstracts B* covers in electrical engineering a field similar to that covered by *Science Abstracts A* in pure physics, and may be obtained by fellows for a small subscription.

The society holds about fifteen meetings each session, for the reading and discussion of papers, for experimental demonstrations and for special lectures, including the Guthrie lecture, given annually by a physicist of international reputation, in memory of the founder of the society. The meetings are usually held at the Imperial College of Science and Technology, South Kensington. In addition, a provincial meeting at some centre of interest for physicists is generally arranged once a year. The Annual Exhibition of Electrical, Optical, and other Physical Apparatus, which is held jointly with the Optical Society at the Imperial College in January, is recognised as one of the most important functions of its kind during the year. At this exhibition the principal manufacturers show their latest productions; research laboratories and institutions and members of the societies arrange exhibits illustrating their recent work; special discourses on physical subjects, accompanied by experiments, are given; and a descriptive catalogue is issued to members which provides a valuable record of each year's exhibition.

A bronze medal is awarded by the Council not more frequently than once a year to persons who have contributed to the advancement of knowledge by the invention or design of scientific instruments or by the discovery of materials used in their construction. It is named the Duddell medal, after

William du Bois Duddell (1872-1917), the eminent electrical engineer long associated with the City and Guilds Institute.

The need was long felt for a corporate body analogous to the Institute of Chemistry which could represent the profession of physics, strengthen the position of workers engaged therein, and also form a bond between the various societies interested in physics and its applications. Up to the time of foundation of the Institute of Physics the physicist had hardly been recognised as a member of one of the professions. The suggestion for its foundation first took practical shape in 1918, when, at the initiative of the council of the Physical Society of London, a conference took place between representatives of that society and of three other societies directly interested in some of the branches or applications of physics, the Faraday, Optical, and Röntgen Societies. The institute was founded on the recommendation of this conference, by the co-operation in the first instance of the Physical, Faraday, and Optical Societies. The first board was nominated by their councils, consisting of seven representatives of the Physical Society and four each of the Faraday and Optical Societies. This board was directed to elect officers, take the necessary steps to frame laws and regulations to govern the institute, and to arrange for its incorporation, which took place in 1920.

Before its incorporation the Royal Microscopical Society and the Röntgen Society decided to participate in the institute, and were given representations on the board.

The objects of the institute are to secure the recognition of the professional status of the physicist; to create and grant diplomas to corporate members, indicative of a high standard of professional competency in physics; and to co-ordinate the work of all existing societies concerned with the science of physics and its applications in the various industries, by securing their special association with the institute—such societies to be called 'participating societies.'

Diplomas are granted to corporate members in order to secure their authoritative recognition as physicists engaged in professional work. Corporate members are divided into fellows and associates, depending upon academic qualifications and professional experience. Ordinary members, who have no authority in the institute, are members of participating societies and others interested and qualified in physics. Annual subscriptions to participating societies are reduced for members who are also members of two or more participating societies, and the publications of such societies are supplied at a reduced rate to any member who is also a member of one of them. Lectures are delivered and published and also a monthly *Journal of Scientific Instruments* (in co-operation with the National Physical Laboratory). Prizes are awarded for the best papers each year. A panel of consulting physicists and an appointments register are kept at the Institute's offices at 1 Lowther Gardens, Exhibition Road, S.W.7

The British Optical Association (founded in 1895, and incorporated in 1899) exists primarily for the purpose of examining opticians and protecting their legal rights, and also for holding meetings to advance scientific knowledge of optics. It issues a monthly review and a journal twice yearly, and has a large library and a museum in its premises at Clifford's Inn Hall, Fleet Street. Examinations for the fellowship of the association, which is not compulsory for opticians but is considered a valuable asset, are held twice yearly in London and the large provincial centres, and grants are made at various colleges towards the training of opticians. During the Great War the association did much good work in connection with the supply of spectacles to the army; and in 1923 it co-operated with the Institute of Ophthalmic Opticians in the foundation of a joint council, which deals with questions arising in connection with the supply of spectacles to insured persons through approved societies.

The Optical Society was founded in 1899 'to promote and advance the theory and practice of optical science.' Membership of the society is open to all persons interested in the science of optics or its applications. Monthly meetings are held at the Imperial College of Science and Technology, South Kensington, and all papers read, descriptions of novel instruments, and experiments demonstrated at the meetings, are published in the *Transactions*, five numbers of which appear annually. The *Transactions*, first published in 1901, form a valuable record of the progress of optical science in the last thirty years, and many important papers on ophthalmic optics have been published by the society.

The Optical Society was the first British learned society to index its *Transactions* according to the decimal bibliographical classification of the *Institut International de Bibliographie*, and published a complete subject index to the first twenty-five volumes of the *Transactions* and an explanatory handbook on this system, in 1926.

From its inception the society has taken an important part in the establishment of optical standards and manufacturing standards for all components of optical instruments. In 1904 it formulated standards for spectacles and eyeglasses, and in 1907 standards for trial cases which are still in general use. The society has co-operated from time to time with the National Physical Laboratory, the British Engineering Standards Association, and other bodies in the establishment of standards to govern the manufacture of instruments.

In 1907 the Thomas Young Oration was founded. At intervals of three or four years the Council invites some one who has attained eminence in some branch of optics or its applications to deliver this oration. In conjunction with the Physical Society an exhibition of scientific instruments is held each year, and on the initiative of the Optical Society steps were taken to hold an optical convention in London in 1905. The convention took the form of a series of meetings of those interested in optics, for the reading of papers and discussion of appropriate matters. At the same time an exhibition of instruments was held. This convention was followed by others in 1912 and 1926, and their great value can be assessed by the rapid growth both of the number of papers published in the *Proceedings* of the conventions and the increased space required for the exhibition.

Authorities on the manufacture, properties and applications of photo-electric cells, from all over the world, attended or contributed papers to a discussion on photo-electric cells and their application which was held jointly with the Physical Society in 1930. Similar discussions were held in earlier years on 'The Making of Reflecting Surfaces,' 'Motor Headlights,' and 'The Microscope.'

The Royal Photographic Society of Great Britain (originally the Photographic Society of London) was founded in 1853, as a result of the enthusiasm engendered by the photographic exhibition at the Great Exhibition, and that organised by the Society of Arts in the following year. The name of the society was changed in 1874; it was incorporated in 1894. To promote the advance of photography it holds weekly meetings, publishes a monthly journal, and arranges an annual exhibition, as well as smaller exhibitions throughout the year. Membership has always been open to both amateur and professional photographers, and the members are organised in groups such as the kinematographic group and the scientific and technical group, which publishes a quarterly journal of abstracts. The society's house in Russell Square contains a library and photographic museum.

The London Mathematical Society, founded in 1865 for the promotion and extension of mathematical knowledge, meets monthly at the rooms of the Royal Astronomical Society in Burlington House, to hear lectures or papers. Sixty-six volumes of the *Proceedings* have been issued, and a quarterly *Journal* containing shorter papers, records of meetings, etc., has been published in addition since 1926. A library for the use of members is housed at University College.

CHEMISTRY

There are a large number of societies connected with chemistry and its applications to industry. The oldest, the Chemical Society, deals with chemistry as a pure science. There are several professional qualifying and educative societies, *e.g.*, the Institute of Chemistry, the Pharmaceutical Society, the Institution of Chemical Engineers, and the Society of Public Analysts. A third group consists of societies devoted mainly to the interests of industrial chemists and manufacturers—*e.g.*, the Society of Chemical Industry and the Association of British Chemical Manufacturers.

The Chemical Society, the oldest chemical society in the world, was founded in 1841. A meeting convened by Robert Warrington was held in the rooms of the Society of Arts on the 23 February, 1841, 'for the purpose of taking into consideration the formation of a Chemical Society.' Professor Thomas Graham occupied the chair and the company numbered twenty-five. It was unanimously resolved 'That it is expedient that a Chemical Society should be formed,' which should have as its objects 'The promotion of chemistry and those branches of science immediately connected with it by the reading, discussion, and subsequent publication of original communications.' A provisional committee of fourteen was appointed to carry this resolution into effect; a circular was issued to a number of chemists inviting them to become original members and to attend the first general meeting of the society which was held at the Royal Society of Arts on March 30, 1814. At this meeting the first officers and council were elected, Thomas Graham being the first president. Bye-laws were drawn up and approved at the annual general meeting in 1842. The society met regularly, and at the close of 1847 had published three volumes of *Memoirs and Proceedings*. By this time the society had between 200 and 300 Fellows, and it was decided to take steps to obtain a Charter of Incorporation. This was granted in 1848. The society consists of Fellows and of Honorary Fellows who are elected on account of their distinguished services to chemistry.

Since its foundation the Chemical Society has actively carried out the objects for which it was formed. Ordinary scientific meetings are held as a rule twice a month from October to June, at which papers dealing with new discoveries in chemistry are read and discussed. Special lectures on chemistry and the allied sciences are also delivered. These meetings are open to the public on the introduction of a Fellow. The *Journal*, which contains original communications sugmitted to the society, is published monthly; in 1930, 400 papers were printed occupying 2,686 pages. *British Chemical Abstracts* 'A' (Pure Chemistry), issued by the Bureau of Chemical Abstracts, consists of abstracts of papers appearing in British and foreign chemical journals. In 1930 11,543 abstracts were published occupying 1,628 pages. Since 1904 the society has issued each year a volume of *Annual Reports on the Progress of Chemistry* which contain an epitome of the important advances made during the year. Other publications issued by the society include two volumes of Memorial Lectures and a volume of Faraday Lectures.

The society has a research fund, established in 1876 for the purpose of assisting those carrying out original investigations by defraying the cost of apparatus and expensive materials. It possesses a comprehensive library containing over 33,600 volumes. This is open for borrowing and consultation to Fellows and also to members of eight allied societies which contribute towards its upkeep.

The Pharmaceutical Society was formed in 1841, and confirmed by Royal Charter in 1843, for the purpose of protecting the interests of pharmaceutical chemists, advancing chemistry and pharmacy, and establishing a uniform system of education as the basis of pharmaceutical practice. The Pharmacy Acts of 1852, 1868, and 1908, gave to holders of the society's qualifications certain legal privileges in regard to titles and the sale and dispensing of poisons, and enlarged its sphere of activity by placing upon it the duty of administering these Acts.

The Institute of Chemistry was founded in 1877 to fill the need for a body whose membership should confer professional status on chemists, as distinct from pharmacists, by enforcing strict rules of professional conduct, maintaining the efficiency and integrity of members, and in general setting up a standard of proficiency. To this end the Royal Charter granted to the Institute in 1885 gives it power to conduct examinations, to issue certificates, and to register chemists qualified to practise the profession of chemistry in its application to legal investigations, to public health, to the detection of the adulteration of food and drugs, to agriculture, and to the arts and manufactures.

The membership comprises approximately 2,000 Fellows and 4,000 Associates, who are engaged in all branches of chemical practice in Great Britain and Ireland, in the overseas Dominions, and elsewhere abroad, and about 800 Registered Students. A candidate for the associateship is required to produce satisfactory evidence of general education and to have completed a four years systematic course of study in chemistry and allied sciences, before presenting himself for the institute's examination. He may claim exemption from examination, however, provided that he holds an approved university degree with first or second class honours in chemistry and has otherwise complied with the regulations. An associate who desires to proceed to the fellowship is required to produce evidence that, for at least three years since his admission to the associateship, he has been engaged in the study and practice of chemistry in a manner satisfactory to the Council, and to pass an examination in a special branch; but he may be exempted from this examination on producing evidence that he has carried out original research of sufficient merit, or that, having been engaged in important analytical, industrial, consulting, or other work of a general or specialised character, he is, in the opinion of the Council, possessed of sufficient knowledge and ability.

Lectures on matters of professional interest are given at the institute's house in Russell Square and before local sections, of which there are eleven in Great Britain and Ireland, and three overseas. The institute maintains an appointments register, administers a benevolent fund, and publishes a *Journal and Proceedings*, in six parts annually.

The original conception of the Society of Chemical Industry is credited to John Hargreaves, who, with his brothers, founded the firm of consulting chemical and metallurgical engineers bearing their name. Hargreaves was actively acquainted with the valuable work done by local societies in the northern manufacturing districts where chemical industries were centred. The first of these local societies was the Newcastle Chemical Society (1868), followed by the Tyne Chemical Society in the same district, and the Faraday Club (1875) in the Widnes and St. Helens area. Hargreaves himself took an active part in the foundation of the South Lancashire Chemical Society in 1879. The development of this last society into a central society of wider range was backed by such leading chemists as Henry Roscoe, Ludwig Mond, Edmund Muspratt, and Eustace

Carey, and in 1881 a meeting was held in the rooms of the Chemical Society, Burlington House, at which the objects of the proposed Society of Chemical Industry were outlined by Roscoe from the chair. Some doubt was expressed as to whether the new society would tend to duplicate the work of the Institute of Chemistry; but the subsequent activities of both would appear to negative these apprehensions. The society received a Royal Charter in 1907, which declared the objects to be the prosecution of the work undertaken by the society of 1881, and 'to promote the application of chemical science to arts and manufactures and also the discussion and diffusion of all knowledge and information and to further by causing to be made or assisting in the making of investigations, inquiries, and reports upon novelties, improvements, inventions, processes, and the practical application of scientific discoveries bearing on the practice of applied chemistry and of any of the industrial arts thereto allied, and to carry on the publication of the journal.'

The society holds annual meetings, generally in principal cities of Great Britain, including London. Much of its activity is carried on through local sections, which (in alphabetical order) are the American, Birmingham and Midland, Bristol, Canadian, Edinburgh and East of Scotland, Glasgow, Liverpool, London, Manchester, Newcastle, Nottingham, South Wales, Sydney, and Yorkshire.

There are also a special Fuel Section and a Chemical Engineering Group within the society. Two medals are awarded to those who have attained eminence in applied chemistry—the society's medal and the Messel medal. The second of these is one of several objects to which is devoted the Messel Fund, a munificent bequest by the late Dr. Rudolph Messel (1847-1920). Another bequest, by William John Leonard, a well-known industrial chemist (*d.* 1923), has been devoted to the fund organised by the Association for the Promotion of Co-operation between Scientific and Technical Societies and Institutions within the British Empire, which has in hand a scheme for 'a central building in London for technical institutions including the Empire Council for Mining and Metallurgical Institutions, the Institution of Petroleum Technologists, the Chemical Society, the Society of Chemical Industry, the Institution of Chemical Engineers, Institution of Mining and Metallurgy, Institution of Mining Engineers, Iron and Steel Institute, and several other important bodies.

'The Society of Chemical Industry has, ever since its foundation, occupied an important position among the scientific societies and maintained a close contact with the chemical industry, the chemical engineering industry, and the fuel industry. As a scientific society it has always been closely connected with the Chemical Society. It has shared with that society the work and the heavy expenses of the Bureau of British Chemical Abstracts; it makes an annual grant towards the cost of the Chemical Society's library, and its members enjoy the privilege of using that library. It has taken an active part in the work of the Federal Council for Chemistry, and its journal contains many notes and a few articles on pure chemistry.'

The society has celebrated its jubilee in 1931, and the quoted paragraphs above are taken from the full account of its history and activities which appear in the special jubilee number of *Chemistry and Industry*, the journal of the society. The society's headquarters are in Finsbury Square.

The Association of British Chemical Manufacturers was formed in 1916 to promote co-operation between chemical manufacturers, to act as a mouthpiece for the industry in dealing with the Government or Government departments on matters affecting chemical manufacturers, and to deal with all questions likely to promote industrial efficiency in the widest sense. The association does not concern itself with labour questions, and is strictly non-political, its object being to assist whatever Government is in power. It is recognised as the authoritative body on questions relating to the chemical and closely allied industries, not only by the Government and Government officials, but by other industrial and trade bodies such as the British Engineering Standards Association, the Pharmaceutical Society, the Medical Research Council, the Federation of British Industries, etc., who often approach it on matters affecting their mutual interests. There are 112 firms which are members, including the most important chemical firms in the country. In addition eleven other associations, representing various sections of the chemical industry, are affiliated to it.

The association keeps a close watch on all new legislation, Government regulations, patent law, tariffs, etc., at home and abroad, and makes representations where necessary to the Government departments concerned. It deals with enquiries from its members affecting the industry, and either provides the information itself or puts the member in touch with the proper department. It maintains a Traffic Committee which looks after the interest of members, vis-à-vis the railway and shipping companies, etc, and assists the industry in devising methods for ensuring greater safety and freedom from accidents. A very important work which it has now in hand is the formulation of model safety rules for chemical works, and the compilation of a text book embodying the experience of the industry in regard to safety measures; at the same time it maintains a regular issue of safety circulars containing information of help to the industry and mainly compiled from reports of accidents from which valuable lessons may be drawn, with notes as to precautions to avoid the occurrence of such accidents in future. A *Quarterly Safety Summary* has recently been started in which is published a collection of all information on safety matters and accidents in the chemical industry, which are likely to be helpful to members.

The association issues every month a printed *Summary of Information on Chemical Trade.* In conjunction with the British Chemical Plant Manufacturers' Association it has a committee studying the question of resistant metals and other constructional materials for use in chemical plant. Similar joint committees are also studying the question of standard contracts for the purchase of chemical plant, while the association has taken the leading part in regard to the questions of standardisation in so far as they affect the chemical industry, which have led to the formation of the British Standards Institution. It maintains close touch with the Chemotherapy Committee of the Medical Research Council and has evolved, in conjunction with it, a scheme for the manufacture of new therapeutical products for extended clinical trials. It organises the chemical section at the British Industries Fair, and every two years it publishes and distributes throughout the world a *Directory* in six languages, giving a classified list of the products made by its members. There is also a special publication dealing with the products of the fine chemical industry. It issues *Proceedings* every month which contain a record of the meetings of the council and the various groups and committees.

There is not much doubt that England's success in the manufacture of heavy chemicals on a large scale during the nineteenth century led to neglect rather than to study of the methods by which the chemical industry could become of the highest value to the country. In other countries, especially Germany, the struggle for commercial existence in the chemical trade led to the careful study of chemical engineering problems connected with the industry, and when the twentieth century began Germany held a leading position in all branches of chemical industry where scientific knowledge and method were important. The stress of the European War—1914-1918—brought this fact home to the whole of the people, and attention was again focussed on the question of chemical plant, its efficiency, design, construction, and working. Lord Moulton, Director-General of Explosives Supply during that period, insisted on the necessity of training 'chemical engineers,' and foreshadowed the Institution of Chemical Engineers. An influential body of opinion was developed in the country in favour of some action by which the study of chemical engineering could be encouraged and its obvious importance to national industry given some place in our educational system. A meeting was called in July, 1918, with a view to establishing an organisation for chemical engineers. In several quarters, however, it was felt that the time was not ripe for a new institution, and accordingly a subject group (Chemical Engineering Group) was formed in the Society of Chemical Industry, which still exists, and continues to promote the study of chemical engineering. Nevertheless, a general feeling grew that a separate institution should be formed to act as a qualifying body for chemical engineers, and early in 1922 the new constitution was drafted and approved, the inaugural meeting took place in London in May of that year, and in December the Institution was formally incorporated with Sir Arthur Duckham, K.C.B., as the first president.

Among the first matters to which the newly-elected council turned its attention was the lack of adequate facilities at universities and technical colleges for proper training in chemical engineering. Apart from the technological courses at various universities, which were limited to trades directly concerned in the vicinity, it must be said that there was only one full-time course in chemical engineering in existence; that at the Imperial College of Science and Technology. There was also an evening course at the Battersea Polytechnic.

A new development, however, soon arose, when funds were raised through a widespread appeal, in which the Institution took a prominent part, for a memorial to the work of the late Sir William Ramsay. Part of this memorial took the form of the establishment at University College, London, of the Ramsay Laboratory of Chemical Engineering.

With a view to increasing and improving the profession of the chemical engineer the council, through its education committee, in 1924 drew up a draft memorandum on 'The Training of a Chemical Engineer,' which, after consultation with all the prominent chemical manufacturers of the Kingdom, was circulated to all universities and technical colleges with an expression of hope that the authorities concerned would make provision for such courses as were outlined. A degree course in chemical engineering has since been established at Glasgow University, and a post-graduate course at King's College, London. A beginning has also been made at the Cardiff Technical College, and still more recently, an additional evening course in London has been inaugurated at the Hackney Technical Institute of the London County Council.

As a corollary to these efforts the council instituted in 1926 an examination for admission to associate-membership. The examination was based on the syllabus of subjects laid down in the memorandum on 'The Training of a Chemical Engineer,' and was organised on a novel plan. The candidates were asked to solve two problems in their own time at their own homes, for which a period of two months was allotted, and they were allowed to consult any literature which might be published on that particular subject. Subsequently, four papers were worked, under ordinary examination conditions, and at the same time the examiners took an opportunity of holding a brief *viva voce* session for each candidate. Correspondence has since shown that this type of examination has created widespread interest. Successful completion of a course of instruction at the Imperial College of Science and Technology, University College, or King's College, London, is recognised as exempting candidates for admission to the Institution from this examination.

Ordinary meetings are held from time to time, as the council may direct, at which papers, afterwards published in the *Transactions*, are read and discussed. The Moulton Medal (senior award in gold) is awarded for the best paper of the year, the author of which need not necessarily be a member of the Institution. The Junior Moulton Medal (in silver, with prize of books) is awarded for the best paper of the year communicated to the Institution and printed in the *Transactions*, graduates and students of the Institution only being eligible. The Osborne Reynolds medal is also awarded annually, in recognition of the most meritorious service towards the advancement of the Institution rendered during the year. This medal was founded in perpetuity by Mr. F. A. Greene. A two-day conference is usually held in December of each year, and the Annual Corporate Meeting, extending over two days, is held in March. In 1927 a series of public lectures was inaugurated.

In 1928 the graduates and students' section of the Institution was formed to organise meetings of special interest to junior members. Among other activities of the institution may be mentioned the appointments bureau for the benefit of members, both employers and employed, and the establishment of a small library.

The Society of Public Analysts and other analytical chemists exists to cultivate the study of analytical chemistry, and also to study the question of adulteration of food, drugs, etc., and to promote the efficiency and proper administration of laws for its suppression. It holds meetings, publishes a monthly *Journal*, and co-operates with the Institute of Chemistry in matters of joint interest.

The British Association of Chemists has been formed recently to improve the status and salaries of chemists, to restrict practice to properly qualified men, and to get the word 'chemist' legally redefined. It has an appointments bureau and provides legal aid and unemployment benefits.

ARCHÆOLOGY, ANTHROPOLOGY, AND ALLIED SUBJECTS

A Society of Antiquaries was founded in London by Archbishop Matthew Parker in 1572, the early meetings being held in the house of Sir Robert

Cotton, the founder of the Cottonian Library. Later they were held at the Heralds College in the rooms of Sir William Dethick, Garter King of Arms. Among other eminent fellows at this early date were John Stow, the historian of London, John Selden, the lawyer, Sir Henry Spelman, the historian, and Sir John Dodderidge, the judge. Two original summonses to meetings, one at least addressed to Stow himself, are preserved in the Ashmolean manuscripts. The society, however, got into bad odour under James I and was suppressed, but in spite of this it certainly continued to exist, and there is evidence of meetings being held down to the end of the Commonwealth, the evidence including a note of the Antiquaries Feast in Ashmole's Diary under date 2 July, 1659. The foundation of the Royal Society probably gave the *coup de grâce*. At any rate there is then a gap until 1707, when the society was revived on the old lines by Humphrey Wanley, librarian to Edward Harley, Earl of Oxford. Among the more prominent members of the reconstituted society were Peter Le Neve, Norroy King of Arms, the first president, Samuel and Roger Gale, Maurice Johnson, George Vertue, William Stukeley, and Thomas Rymer. The first meeting was held on 5 December, 1707, at the Bear Tavern in the Strand. Later meetings were held at the Young Devil Tavern and other inns. The draft minutes of these early meetings are among the Harleian MSS. in the British Museum. In 1717 the society was more formally reconstituted, and from that date the minutes of the meetings form a series of some fifty volumes in the possession of the society. The society received its Royal Charter in 1751, and was later granted the use of rooms in Somerset House, and later still in Burlington House.

The objects of the society are set forth in the Charter as the study and investigation of antiquity and the history of former times. In furtherance of this it has published *Vetusta Monumenta* (1747-1906), *Archæologia* (1777 in progress), *Proceedings* (1843-1921), *The Antiquaries Journal* (1921 in progress), *Reports of the Research* Committee (in progress), as well as a considerable number of monographs such as the *Wardrobe Account of* 28 *Edward I* (1787), *Layamon's Brut* (1847), *Ordinances for the Government of the Royal Household* (1790), and the *Norman Exchequer Rolls* (1840-4). It has also issued a certain number of county archæological surveys. In more recent years it has carried out much excavation work in this country, its more important contributions to this branch of archæology being the excavation of Silchester (Calleva Atrebatum), Old Sarum, Stonehenge, Hengistbury Head, the Swarling urnfield, the Ospringe Roman cemetery, the Roman site at Lydney, and the Roman fort at Richborough (Rutupiae) still in progress. The society has too, for many years, watched and investigated excavations in the city of London.

The society has a large and comprehensive library, including a valuable collection of MSS., among which may be mentioned the Winton Domesday (twelfth century), the Lindsey Psalter (early thirteenth century), Wardrobe Accounts of Edward I and II, the Antiphonar of St. Cosmos and Damian (Italian fifteenth century), the Inventory of the

Jewel House taken on the death of Henry VIII, and a collection of letters addressed to Oliver Cromwell. The society also possesses one of the few extant copies of the Book of St. Albans, printed in 1487, a good many other incunabula, and a collection of early portraits and pictures.

The Royal Asiatic Society was founded by Henry Thomas Colebrooke, the Sanskrit scholar, who, with others interested in Oriental studies, drew up a prospectus and became director when the society was formally constituted as the Asiatic Society of Great Britain and Ireland at a meeting at the Thatched House[1] in St. James' Street in 1823. The aims were research into the sciences, arts, institutions, languages, and customs of Asia, ancient and modern, including the connections of western Asia with other lands, with the objects of advancing knowledge at home and facilitating the improvement of conditions of life in Asia. The King was patron and the Rt. Hon. Charles Watkin Williams Wynn, M.P. (President of the Board of Control) the first president, which position he held for eighteen years. The charter of incorporation was granted in 1824, and the society was housed at 14 Grafton Street in that year. Transactions were at first published at irregular intervals, but in 1834 a journal was founded; and in 1828 the Oriental Translation Committee and original Oriental Translation Fund were formed for the purpose of publishing translations of valuable Oriental works. The translators received money awards, and their work was distributed free or at low cost to the society's subscribers. In connection with this undertaking a corresponding committee was formed in Calcutta, which collected historical material and made agricultural investigations in India. The work of this committee met at first with much success, but after 1839 interest in the society's work at home fell away. To improve the position its home was moved to 5 New Burlington Street, where there was room for the expansion of the library and museum, and lectures were instituted. The society roused much public interest as the chief introducer of the great work on cuneiform inscriptions in the years round 1850, by Major (afterwards Sir) Henry Creswicke Rawlinson, who became director in 1862, and held that post until his death in 1895. Membership, however, continued to decline, and the work of the Oriental Translation Fund and the Committee of Correspondence gradually came to a stop. A move was made to Albemarle Street in 1869, and the museum was transferred to the India Office, and subsequently to the Victoria and Albert Museum. About 1877 the tide turned; since then the growth of the society has been almost continuous; it has long since reached a position of stability and wide influence, and the journal has become a publication of established excellence. Among the enterprises undertaken have been the promotion of Oriental studies in the universities, the institution of gold medals, and the management of a new Oriental Translation Fund, begun by Mr. F. F. Arbuthnot at his own expense in 1891. Since 1919 the home of the society has been at 74 Grosvenor Street.

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[1] The Thatched House Tavern was a well-known house, which had a large meeting-room. It was number 75 St. James's Street from 1711 until in 1845 it was removed to the next house, its first site having been acquired for the Conservative Club. It remained until 1865, when the Civil Service Club was built on the second site. Among its other claims to fame, the Thatched House was the meeting-place of the Society of Dilettanti from its foundation in 1734 until 1843. This was a society of noblemen and gentlemen who, brought together by admiration for antique art, endeavoured to encourage and improve the arts in England, and in 1764 and subsequently, sent expeditions to Greece and the Levant for the study of antiquities. The society published the results of these and certain other investigations in richly illustrated volumes and in engravings.

The two societies, the British Archæological Association and the Royal Archæological Institute, date their common origin from a meeting at the house of Mr. Thomas Wright, F.S.A., in 1843, when it was decided to establish a central board for the purpose (among other objects) of collecting from correspondents all over Great Britain information on archæological matters. The time was ripe for the initiation of such a task, for the network of railways was beginning to be spread over the country and almost daily fresh discoveries were being made.

A small group of persons interested formed themselves into a central committee to supervise the issue of a journal under the name of *The Archæological Journal*, which was to record the information so collected. No subscriptions were asked for from persons joining the association, the central committee proposing to rely for its revenue on voluntary donations and on moneys to be received from the sale of its publications. The scheme was so successful that the central committee decided to organise what was then a new venture, that of holding a meeting in some provincial centre, and in September, 1844, the first congress was held at Canterbury under the presidency of Lord Albert Conyngham, F.R.S., F.S.A., afterwards Baron Londesborough. This proved such a success that both societies have since then held similar annual congresses, which have so aroused local interest in archæology that no county is now without its county society.

In 1844 acute disagreement arose between the two secretaries with regard to the conduct of Mr. Thomas Wright, who, while acting as assistant editor of the *Archæological Journal*, at the same time published on his own behalf the *Archæological Album*, a collection of articles on archæological subjects, which it was thought might prove prejudicial to the journal. Attempts to heal the dispute proved unsuccessful, the president resigned his office, and the cleavage became definite.

The association was fairly equally divided, and as it had already been decided to hold the second annual congress at Winchester and neither side was willing to give way to the other, the curious position came about that two congresses were held in Winchester in 1845, both under the name of the British Archæological Association. Both appear to have been successful, which shows the great interest which was then being aroused in archæology. At the close of the second congress the Marquis of Northampton, its president, announced that it had been decided by his side to adopt the name of the Archæological Institute of Great Britain and Ireland in order to put an end to the confusion which was being caused by reason of there being two bodies with the same name.

The *Archæological Journal*, which was published by Mr. J. H. Parker, of Oxford, at his own expense, any loss which might be sustained being borne by him, became the organ of the institute, and the association established its own journal under the title of the *Journal of the British Archæological Association*.

Fifty years later, in 1893, proposals for amalgamation were made but the negotiations failed, because of inability to agree as to the persons to be nominated as officers of the proposed amalgamated society.

The Institute received its Royal Charter in 1884.

The origins of the Royal Anthropological Institute are traced in Sir Arthur Keith's presidential address to the Institute in 1917 (*Journal R.A.I.*, vol. xlvii, pp. 12 *seq.*), and are full of historical interest. Dr. Thomas Hodgkin, physician to Guy's Hospital and an eminent member of the Society of Friends, was active in the movement for the abolition of slavery in British colonies (1833), and in 1837 took the lead in the foundation of the Aborigines Protection Society. Within this body there soon developed two divergent conceptions of the chief duties of white men towards native peoples—according to the one, the 'native' was to be regarded as an object for scientific study as well as for protection; according to the other he must, above all, be converted and civilised. Sir Arthur Keith assigned these views respectively to the 'student party' and the 'missionary party.' The two could not work together, and in 1843 Hodgkin himself and others formed the

Ethnological Society, to give effect to the scientific objects of the 'students.' In that year a committee of the British Association, which included James Cowell Prichard and Richard Owen, had completed a questionnaire for the guidance of travellers and others coming into contact with native peoples. From this followed the well-known publication, *Anthropological Notes and Queries*, which, with the assistance from the British Association, has been maintained through a series of editions to the present time. So also has the happy contact, then established, between the representative anthropological society in London and the appropriate section of the British Association.

To this day it is impossible to assert that the builders and supporters of the British Empire have recognised man as the proper study of mankind, even though the Empire embraces all sorts and conditions of them. The Ethnological Society, though it drew to itself the leaders of the science which it represented, achieved no wide appeal. In 1859 John Hunt, its secretary, conceived that the appeal might be widened by reform within the society itself; his methods, which included excursions into politics, did not generally commend themselves to the members, and in 1863 he and a handful of his supporters, including Richard Burton, formed a seceding body, the Anthropological Society. They carried their activities well beyond the strict bounds of science, and they succeeded in their object of attracting non-scientific attention. The two bodies remained apart until 1871, when they reunited under the presidency of Sir John Lubbock as the

Anthropological Institute of Great Britain and Ireland. Difficulties were even then not wholly composed, for 'ethnology' as represented by Lubbock was now in the ascendant, and some of the anthropologists formed a London Anthropological Society which survived only from 1873 to 1876. The institute, which acquired the Royal title in 1907, has fought hard for its ideals in the face of a long period of financial restriction; it publishes a *Journal* and the monthly periodical, *Man*, as well as monographs, and it has carried out or assisted much co-operative effort in the direction of ethnographical survey and exploration on both the archæological and the modern side, and has not ceased to press the claims of anthropology to fuller recognition in higher education.

The Palestine Exploration Fund owed its inception in 1868 to a number of people who realised how little was known from a scientific point of view of the Holy Land, and aims at the investigation of its topography, geology, archæology, and manners and customs, for purposes of biblical illustration. The Society is not a religious body and has always abstained from any controversy. A number of surveys and maps on various scales have been made, and archæological excavations carried out. A *Quarterly Statement*, describing all important discoveries, is published, in addition to any valuable series of memoirs, annuals, and other volumes. A number of men of world-wide repute have been associated with the work, among them Lord Kitchener and Professor Sir Flinders Petrie.

The Hellenic Society owes its inception to the action of Mr. George A. Macmillan, now hon. Fellow of Lincoln College, Oxford, and Professor Sayce, who approached persons who had travelled in Greece with a view to forming a society of those interested in Greek archæology, language, and literature. The suggestion was given an enthusiastic reception, and the inaugural meeting was held in 1879. The constitution of the society was settled at a meeting held in the rooms of the Royal Literary Fund, Adelphi Terrace, in 1880. The society owed much in its early years to the constant interest of Sir Charles Newton, keeper of Greek and Roman antiquities at the British Museum. Through the *Journal of Hellenic Studies*, begun in 1880, many very important contributions to Greek archæology, etc., have been published, and a leading part in the development of research into the subject has been taken by the governing body, on which most of the best Greek scholars and archæologists have served from time to time. Supplementary papers and facsimiles of Greek manuscripts have also been published. The society took part in the foundation of the British School in Athens and assists it with grants, as has also been the case with the exploration funds for Asia Minor, Cyprus, and Crete. It works in friendly co-operation with the Roman Society, founded in 1910, which occupies part of the older society's premises in Bedford Square, where there are a fine library and collection of photographs. A special committee was appointed in 1910 to consider the position of Greek in education, and issued a report in 1912; and another on the further popularisation of the classics has arranged lectures for schools and issued advisory pamphlets. On its advice student associates are now admitted to the society at a low rate of subscription. The general meetings of the society are held four times annually in the rooms of the Society of Antiquaries, Burlington House. Sir Richard Jebb was president from 1890 to 1905. A new president is now elected every three years.

The Egypt Exploration Society was formed in 1882 to make surveys, explorations, and excavations in Egypt, and to publish the results. Realising the importance of safeguarding what remains of this ancient civilisation, the society has included among its activities the copying of paintings and inscriptions in order that a record may be preserved in case of their destruction. The memoirs of the archæological expeditions sent out almost every winter for forty-seven years, on which a large number of archæologists and students have taken part, have been supplemented since 1914 by the *Journal of Egyptian Archæology*, and by a series of volumes of papyri. The material from these expeditions has been systematically collected and published, many monuments have been discovered, and several repaired and restored, and the objects found presented to museums in London and elsewhere.

GEOGRAPHY

The original impulse to the foundation of the Royal Geographical Society came from the Raleigh Dining Club, which was founded in 1827 and met at the Thatched House in St. James's Street. The club consisted of travellers, and the globe was mapped out in divisions, each division being represented by at least one member who had been there in person. Gradually it came to be felt that a more fully organised institution for the study of geography was desirable, and a committee of six members of the Raleigh Club (Sir John Barrow, Dr. Robert Brown, Sir John Hobhouse, afterwards Lord Broughton, Sir Roderick Murchison, Mr. Mountstuart Elphinstone, and Mr. Bartle Frere) was chosen to consider the subject. This committee was much helped by Admiral Smyth, who had previously enrolled many names under a scheme of his own for the formation of a geographical society, and in 1830 the new society was founded at a meeting in the rooms of the Horticultural Society in Regent Street, with Viscount Goderich (afterwards Lord Ripon) as first president. The Raleigh Club was continued in close connexion with the society, and ultimately became the Geographical Club, which entertains the lecturer and special guests before evening meetings. In 1859 a Royal Charter was granted to Sir Roderick Murchison who was then president. The first home which was the property of the society was in Savile Row; evening meetings were then held, first in the hall of the Royal Society, and, after the wing of Old Burlington House in which it was situated was pulled down, in the Royal Institution for a short period. From 1870 onwards meetings were held in the theatre in Burlington Gardens, at first by permission of the University of London, and after it had moved to South Kensington, by that of the First Commissioner of Works. In 1911, under the energetic presidency of Lord Curzon, the society followed the university to Kensington, buying Lowther Lodge in Kensington Gore. Extensive new buildings, including a lecture hall, a new library, map-room, and stores, etc., were opened to the east of Lowther Lodge on the occasion of the society's centenary in 1930. The society has never confined its membership to travellers and explorers, or writers on geography, but includes many persons who are interested in the subject and desire to support the society's work for the promotion of geographical knowledge. Women were first elected as members in 1892, but objections having been raised, no more were elected till 1913, since when large numbers have become members. Both evening and afternoon meetings are held, the latter for the more technical communications. The transactions are printed in the monthly *Geographical Journal*, and the society also publishes special works and reproductions of early maps. It possesses a fine library, a museum, and map collections, the latter being open to the public, in consideration of which the society receives a Government grant. Geographical exploration is encouraged by grants and the loan of instruments. Many of the expeditions so assisted have been of historic importance, such as the Livingstone and the Burton and Speke expeditions, later African exploration, and the Emin Pasha Relief Expedition. In the years before the Great War the larger part of the money available for grants was devoted to arctic and antarctic exploration, notably by the expeditions of Captain

Scott, Sir Ernest Shackleton, and Sir Douglas Mawson. Since the war the three Mount Everest expeditions have been organised in conjunction with the Alpine Club, and contributions made and instruments lent to a number of other exploratory undertakings. An important side of the society's work has always been the instruction of travellers in surveying and field astronomy, and a diploma in surveying is awarded after examination.

In 1846 a number of distinguished people representing literature, science, geography, politics, bibliography, and the navy and army, met, with Sir Roderick Murchison in the chair, at the London Library, and founded the Hakluyt Society. Sir Roderick Murchison was the first president, and held the office till his death in 1871.

The society has for its object the printing of rare and valuable narratives of voyages, travels, naval expeditions, and other geographical records. Books of this class are of the highest interest to students of history, geography, navigation, and ethnology; and many of them, especially the original narratives and translations of the Elizabethan and Stuart periods, are admirable examples of English prose at the stage of its most robust development.

The society has not confined its selection to the books of English travellers, to a particular age, or to particular regions. Where the original is foreign, the work is given in English, fresh translations being made, except where it is possible to utilise the spirited renderings of the sixteenth or seventeenth century. The works selected for reproduction are printed (with rare exceptions) at full length. Each volume is placed in the charge of an editor especially competent—in many cases from personal acquaintance with the countries described—to give the reader such assistance as he needs for the elucidation of the text. These editorial services are rendered gratuitously. In all cases where required for the better understanding of the text, the volumes are furnished with maps, portraits, and other illustrations, the author's original plates, woodcuts, or drawings (if any) being reproduced in facsimile.

One hundred volumes were issued from 1846 to 1898; sixty-six volumes have been issued in the thirty-three years ending 1930.

Economic Science and Statistics

The story of the foundation of the Royal Statistical Society has a special interest for the British Association. The society owes its genesis to one of the association's sections. In the archives of the association it is recorded that the establishment of its Section of Statistics (afterwards Economic Science and Statistics, Section F), followed upon the presence of L. A. D. Quetelet, the Belgian social statistician, astronomer, and meteorologist, at the Oxford meeting in 1832. The establishment of the section was regarded with misgiving by those who wished to restrict the interests of the association to 'pure' science, and the section was given, at first, a limited field. Quetelet attributed to the functions of statistical enquiry a much wider range than the association was prepared to accord. He therefore suggested the formation of a society to Charles

Babbage, the Lucasian professor of mathematics at Cambridge. There followed, in 1834, a public meeting in London, at which the Statistical Society was founded with the object of procuring, arranging and publishing 'facts calculated to illustrate the conditions and prospects of society.' The first president was the Marquis of Lansdowne, Henry Hallam was treasurer, and among the members of the council were Babbage, Thomas Robert Malthus, the economist, Thomas Tooke, one of the earliest advocates of Free Trade, and William Whewell, afterwards Master of Trinity College, Cambridge, who had been one of the sternest opponents of the establishment of the British Association's Section of Statistics.

The society, like others, had a succession of homes in its earlier years, being housed successively by the Literary Society in St. Martin's Place, in Regent Street, in the London Library (St. James's Square), and in King's College, before it found its present quarters in Adelphi Terrace. It is of interest in this connection to find the economist, William Newmarch, and others, endeavouring to form a federation of London societies as a limited liability company; while an effort was initiated by William Guy, president of the society in 1873-5, to obtain and add to the Banqueting Hall in Whitehall as a centre to contain 'the whole of the learned and scientific societies in London.'

The Royal Statistical Society received the Royal Charter in 1887. Among its earliest investigations were such social and practical questions as vital statistics, poverty and wealth, taxation, transport, and the methods and desiderata of the census; and it has not ceased to study 'the complex relations of modern society in its social, economic, and political aspects,' and especially 'such facts as can be stated numerically and arranged in tables.' It has originated and conducted many special enquiries, issues a journal and other publications, and maintains a valuable library, which, like others, formed an important source of information to Government departments during the Great War.

The Royal Economic Society, which exists to further knowledge of the science of economics, achieves its object by the issuing of a number of publications which are supplied free to members, and include a monthly journal (with an annual supplement or economic history), statistical bulletins of conditions in Great Britain and Europe, and special memoranda. The society also publishes books which are supplied to members at reduced rates, and has an arrangement by which members can use the library of the London School of Economics. Founded in 1890 as the British Economic Association, the society received a Royal Charter in 1902.

PSYCHOLOGY AND EUGENICS

The British Psychological Society (originally named the Psychological Society) was founded in order to 'advance scientific psychological research and to further the co-operation of investigators in the different branches of psychology.' The inaugural meeting, over which the late James Sully presided, took place in 1901. Only one officer, A. F. Shand, was at first appointed, who carried out the duties of treasurer and secretary. These offices were separated soon after and W. McDougall became the first treasurer. A committee was also set up, and membership of the society was limited to those 'who are recognised teachers in some branch of psychology or who have published work of recognised value.'

Meetings were at first held about four times yearly, generally in the psychological laboratories of different universities, and were usually presided over by the head of the laboratory in which they happened to be held. In 1911 Clifford Sully was appointed the first librarian of the society.

In 1914 the society took over the publication of the *British Journal of Psychology* (founded in 1904) and its monograph supplements. Subsequently this journal gave birth to two daughter-journals—the *British Journal of Medical Psychology* in 1920, and (by incorporation of the *Forum of Education*) the *British Journal of Educational Psychology* in 1931. The editors of these journals became *ex officio* members of the society's council, which had replaced the committee in 1919.

In 1919 membership of the society was extended to all who were interested in psychology, and within it three sections were established—educational, industrial, and medical. To these the æsthetics section was added in 1922. In 1920 a Scottish branch of the society was established, and subsequently a Birmingham branch was formed. In 1923 a committee for research in education was appointed by the society with a grant from the latter for the expenses involved in the work of collating educational research throughout the country and of answering inquiries thereon.

The library of the society, chiefly composed of technical journals, is housed in the premises of the Royal Anthropological Institute, where, of late, its London meetings have often been held. The secretarial offices are at 121a Gloucester Road, S.W.7.

The National Institute of Industrial Psychology, which was founded in 1921, is controlled by a council of scientists, industrial employers, and leaders of labour. This council delegates its powers to an executive committee. The first president of the Institute was the late Earl of Balfour, who was succeeded by Viscount D'Abernon. Dr. Charles S. Myers, formerly director of the psychological laboratory at Cambridge, held the directorship of the Institute from its foundation until 1930, when he assumed the newly created office of principal, Dr. G. H. Miles, Assistant Director since 1921, succeeding to the directorship.

The institute has a staff of some forty industrial and vocational investigators and superintendents. It maintains a library of books and journals on industrial psychology and publishes a quarterly journal and research monographs.

Broadly speaking, its aims may be described as the increase of efficiency and happiness in industry by improvements in working conditions made primarily from the worker's standpoint. At first the institute confined itself mainly to such problems as fatigue, boredom, movement study, and selection and training of personnel. But it is now extending its scope to organisation, transport, machine design, etc., since it has been found that even such apparently material problems can profitably be studied from the human, as well as from the purely mechanical, point of view.

A considerable amount of laboratory and other research is undertaken by the Institute, thanks to the generosity of the Carnegie Trust and Rockefeller Foundation. Its industrial work is carried out in factories at the request of the management, who defray the expenses of the investigation. Trade Unions have contributed to the institute's appeal funds.

On the vocational side of the institute, mental and physical tests are employed for advising those who are in doubt about the choice of an occupation (vocational guidance) and for the use of firms in selecting applicants for employment (vocational selection).

The institute provides lectures for courses on 'Industrial Psychology' for the London School of Economics and 'Vocational Guidance' for the London County Council. Recently courses on 'Industrial Psychology' have also been given for managers, foremen, employment officers, etc.

The specific study of eugenics was begun by Sir Francis Galton in the last century and had already become the subject of popular interest in the early years of this one. Mrs. Neville Rolfe was the first mover in the formation of the Eugenics Society, founded in 1908 as the Eugenics Education Society, the aim of which is to popularise the principles of eugenics, which are to bring all matters pertaining to parenthood under the domination of eugenic ideals and to spread a knowledge of the laws of heredity so far as they are surely known, and so far as that knowledge may effect the improvement of the race.

The society publishes a quarterly journal, *The Eugenics Review.* The first International Eugenics Congress was held in London in 1912, largely through the influence of the society, which may, therefore, claim some share in the inception of the international eugenic movement. The society has worked steadily on behalf of income-tax payers for allowances for children, and a bill has been prepared to legalise voluntary eugenic sterilisation, which will shortly be introduced in Parliament. It has also encouraged and assisted an investigation into the relation between heredity and social inadequacy in an East London area, and is about to publish the results. A book is being edited by the society on prognosis in hereditary disease, and a schedule is being prepared for the detailed recording of pedigrees.

BOTANY, AGRICULTURE, GEOLOGY, ZOOLOGY

The Linnean Society of London takes its name from the Swedish naturalist, Carl von Linné (1707-1778). On the death of his son in 1783 his collections of zoological specimens and minerals, and his herbarium, library, and manuscripts, were offered for a thousand guineas to Sir Joseph Banks, who had previously negotiated for the purchase of the herbarium. Banks refused the offer, but upon his recommendation the collection was bought by a young doctor, James Edward Smith. The possession of these collections gave fresh impetus to an idea of Smith's of forming a new natural history society to supplant an existing one of which he and others had a very low opinion; and in 1788, with the help and advice of two friends, Thomas Marsham and the Rev. Samuel Goodenough (afterwards Bishop of Carlisle), the Linnean Society was founded. It was granted a Royal Charter in 1802, and an additional Charter in 1904,

During the first forty years of the society's existence, Smith (who was knighted in 1814) was regularly re-elected president. He died in 1828 and directed by his will that his collection should be offered to the society for £5,000. The price was subsequently reduced by the executor to 3,000 guineas; and this sum was collected by the society by the sale of all its invested funds, by a subscription of some thousand pounds, and by raising £1,150 by bonds. The debt thus created was not extinguished till 1861.

In 1886 a regulation came into force by which no president was elected more than four years in succession; and the chair is now held alternatively by a botanist and a zoologist. From 1823 to 1829 there was within the society a Zoological Club, founded because some of the Fellows of the society thought that zoology was neglected by it. The club came to an end in 1829, soon after the foundation of the Zoological Society, but in its corporate capacity had no connection with that foundation.

The objects of the society, as defined by the

Royal Charter, are: 'The cultivation of the science of natural history in all its branches, and more especially of the natural history of Great Britain and Ireland.' To this end meetings are held twice a month from October till May, and papers are read and discussed. The *Transactions* and a *Journal* are published, as well as formal reprints, agenda, and obituaries, and a list of the society. There is a library containing 50,000 volumes in addition to the books which belonged to Linné, and the collections of Linné and Smith, and several smaller old collections, are still in the possession of the society, but otherwise its collections have been dispersed (*cf.* Chap. IX, p. 279). The headquarters are in Burlington House.

The Horticultural Society of London was founded in 1804 at a meeting summoned by John Wedgwood, and held at the house of Mr. Hatchard, the well-known bookseller in Piccadilly. At this historic meeting there were present the Rt. Hon. Charles Greville, the Rt. Hon. Sir Joseph Banks, P.R.S., Richard Anthony Salisbury, F.R.S., William Townsend Aiton, William Forsyth, J. Dickson, and John Wedgwood, who was in the chair.

Its objects were defined as being 'to collect every information respecting the culture and treatment of all plants and trees, as well culinary as ornamental' and 'to foster and encourage every branch of horticulture.' The first president was the Earl of Dartmouth. The society received a Royal Charter on the 7 April, 1809. In 1861, under the presidency of H.R.H. Prince Consort, a new Charter was granted and the style and title was altered therein to the Royal Horticultural Society. In 1899 a supplementary Charter was granted to meet the altered conditions. This Charter, due to the remarkable development of the society, was replaced by a new Charter in 1928.

The society first held its meetings at Hatchard's, and then in the offices of the Linnean Society in Gerard Street, Soho. In 1818 it acquired offices at 21 Regent Street (then called Waterloo Street); in 1859 offices were taken at 8 St. Martin's Place, Trafalgar Square; and in 1861 the headquarters were transferred to South Kensington, after taking over the gardens on the site where the Natural History Museum now stands. In 1888 another move was made and the Drill Hall of the London Scottish Volunteers in Buckingham Gate and offices at 117 (then 111) Victoria Street, were rented. Owing to the energies of Sir Trevor Lawrence and other members, the society received a new lease of life, and since 1887 it has reached such a flourishing condition that on the occasion of its centenary in 1904 new offices and an exhibition hall in Vincent Square, Westminster, were built. Even these did not meet the increasing requirements of the society so that in 1928 a new hall, in close proximity to the old hall, in Greycoat Street, of twice the floor area, was constructed and the offices in the Vincent Square building remodelled for the administration in 1930.

The society has always kept a garden for the practical side of its work; at Kensington and Ealing in its early days; then at Chiswick, and in 1903, Sir Thomas Hanbury gave in trust the gardens at

Wisley, which have since been considerably enlarged. At the gardens standard collections of many of the best varieties of garden flowers are maintained, whilst trials of flowers, fruits, and vegetables are continuously carried out. In the laboratory research work of a horticultural character is carried on, and a number of students are trained in the science of horticulture. Examinations in horticulture are held regularly for the National Diploma (recognised by the Ministry of Agriculture and Fisheries), and for teachers.

The society has been responsible for the introduction of many plants to the gardens of the world through its collectors or its association with plant collecting expeditions.

The society's publications have been numerous. Its records have been maintained from the earliest days, first as *Transactions*, then as *Proceedings*, and then as the *Journal*. In 1921 it took over the publication of the oldest illustrated magazine—*Curtis's Botanical Magazine* which first appeared in 1787, and recently it has published in six volumes, the *Index Londinensis* revision of Pritzel's *Iconum Botanicarum Index*. The Lindley Library of some 12,000 volumes is maintained at its offices, and is one of the most complete horticultural libraries in the country.

The society has held, practically throughout its whole existence, regular exhibitions at fortnightly intervals, besides many other exhibitions. On the occasion of these exhibitions its scientific and fruit and floral committees meet, new plants are examined, awards are made, and lectures are given.

At the annual dinner of the Smithfield Club, held at the Freemasons Tavern, Great Queen Street, in 1837, a scheme for the foundation of an English agricultural society, on the lines of the Highland Society, was first formulated by Earl Spencer, its originator. The society, now the Royal Agricultural Society, was actually established as the English Agricultural Society at a meeting, also in the Freemasons Tavern, in 1838, when a large number of prominent men of the day gave it their support. Earl Spencer was the first president, and among other early supporters may be mentioned Sir Harry Verney, termed the 'father' of the society, and Sir Thomas Dyke Acland, who was a trustee for many years. There was some dissatisfaction among the farmers who attended the meeting, and they proceeded to form what was intended to be a rival society called the Farmers' Central Society of Great Britain and Ireland, but the opposition was not long persisted in and the society became, eventually, a protectionist body, the repeal of the corn laws being then a burning question. The aim of the Agricultural Society was, from its inception, to advance and encourage science as applied to agriculture, and thus improve the practice of farming—an aim embodied in its motto: 'Practice with Science.' All political activity and discussion was eschewed.

The society made rapid progress and quickly gained an assured position. Reports were invited on many subjects, and prizes offered for essays, for ploughing matches, for the best cultivated farms, and for improved implements. The Royal Veterinary College was subsidised to give lectures and demonstrations on the diseases of farm animals. It was decided to have the headquarters of the society and general meetings in London, but to hold annual shows for stock, produce, and implements in the provinces, in order to give more opportunity to be present to the 'resident yeomanry' of the country, and the first was at Oxford in 1839. It was very successful and has become historic in agricultural annals, and in the following year a Royal Charter was granted to the society. The shows continued to be held in various provincial centres till 1902, the one at Windsor in the year of the Great Exhibition being particularly noteworthy. The society then acquired a hundred acres of land at Park Royal, Willesden, and three shows were held there. This policy, however, proved disastrously unsuccessful. The constitution of the society was reviewed, a new Charter granted, and the method of election of members of council altered; they are now chosen on a county basis according to the number of members in each county. In 1906 the annual show was again held in the country, as it has been each year since, with the exception of 1917 and 1918. This policy marked a turning point in the history of the society, which is now strong and successful. A journal has been published since 1840, and the society possesses a fine library in its premises in Bedford Square. Members have the privilege of receiving the advice of consultant botanists, chemists, etc., and of the Principal of the Royal Veterinary College, at reduced rates, and subsidies are paid to various bodies engaged in agricultural research. With a grant from the Empire Marketing Board a quarantine station has been opened at the East India Docks, so that British livestock may be exported to the Dominions without involving any risk of carrying foot and mouth disease overseas.

In 1838 the plot of ground enclosed by the Inner Circle of Regent's Park was a nursery garden, having been originally intended for the erection of a royal palace and excluded from the general plan for laying out the park. It was secured by a few London residents, notably Mr. P. Barnes, who felt that London should possess a botanical society and garden, the gardens at Chelsea and Chiswick not being strictly botanical gardens, and those at Kew being in those days somewhat inaccessible to Londoners. The new society was established as the Royal Botanic Society of London and was granted a Royal Charter in 1839. In fifty years it had only four presidents, the Dukes of Richmond and of Norfolk, the Prince Consort, and Lord de la Warr. The eighteen acres of ground which had been secured were laid out as a garden which was designed to be both botanical and ornamental, and included a lake, a large mound, conservatories, an exhibition ground, a herbaceous garden with plants arranged in their natural orders, and garden and greenhouses for medicinal and economic plants, etc. There was also a museum, with a meeting room and a secretary's house. The gardens were much used by members for recreation and for garden parties, etc., and flower shows were held yearly. The scientific study of botany was encouraged by giving free admission to students from a number of colleges and schools, and to members of natural history societies and similar bodies, supplying cut specimens for teaching purposes and study, and by lectures in the museum. There were also a school of practical gardening and a meteorological station. A decision on the part of the Government not to renew the society's lease unhappily pointed in 1931 to the disbanding of the society.

The Geological Society was founded in 1807 by eleven members of the Askesian Society and the British Mineralogical Society. Most of the names of the eleven are now famous, among them being Humphry Davy, Dr. Babington, George Greenough and William Allan. They were not all geologists in the modern sense, but at that time the term was more elastic—indeed it had only been introduced some thirty years before. The beginning of the society was modest, for it was founded in a tavern, and Davy described it as 'a little talking Geological Dinner Club!' But its membership increased very quickly, and within a year of its foundation it formed a committee with the laudable intention of standardising geological nomenclature. It is interesting to note that nearly a hundred years later a committee was formed by the British Association for the same purpose.

In 1809 the 'Dinner Club' was re-formed as a society, and there followed a heated disagreement with the Royal Society, in which the new society refused to be 'dependent upon, nor subservient to any other.'

Having thus declared its independence the society entered upon a period of great activity. Among the names of its new members one finds those of the famous founders of geology—Conybeare, Buckland, Sedgwick, Lyell, and others. *Transactions* were first published in 1811, and it was through the assistance of the society that the early geological maps of the British Isles were produced. The society was incorporated by Royal Charter in 1825, and it played an important part in the completion of the Geological Survey of the 1830's. A notice of the important geological collection formed by the society, but for the most part no longer retained by it, will fall more appropriately in the later chapter on museums (IX).

The apartments of the society are now in Burlington House. A notably complete history of the society, by H. B. Woodward, was published in connection with the centenary meeting in 1907.

About 1836 the London Clay Club was founded for the main purpose of collecting shells from the Tertiary clays of the London area, and at a meeting of this club there was first formulated a suggestion that the publication of Sowerby's *Mineral Conchology*, which had been in progress since 1812, might be expedited by widening the appeal for funds. This proposal was followed in 1847 by a meeting in the rooms of the Geological Society, then at Somerset House, at which the Palæontographical Society was founded, with Sir Henry De la Beche as president, in order 'to figure and describe as completely as possible a stratigraphical series of British fossils.' This and kindred objects the society has not ceased to pursue.

The Geologists' Association owed its inception to a letter which appeared in the *Geologist* in August 1858, headed 'Proposition for an Association of Amateur Geologists,' and signed 'W. J. Hayward.' The writer of the letter was never discovered, but a meeting was convened and the Association launched by a body of North London men, in North London. While consistently encouraging amateur geology, and particularly field geology, the Association includes a large number of professional workers among its members, who number at present over 1,000. Excursions are held for half or whole days on Saturdays, and for longer periods at Easter, Whitsun, and in the summer. The long excursions are not confined to the British Isles. Evening meetings are held at University College, where the library also is housed. All the officers being honorary officials, the funds can be devoted to the publication of the *Proceedings of the Geologists' Association*, which have a high reputation for the quality of the reports and papers they contain.

The Mineralogical Society of Great Britain and Ireland was founded in 1876, with Henry Clifton Sorby as first president, its object being to advance the study of mineralogy and petrology. Until 1881 meetings were held in various places in Great Britain, but since then all have been in London except four meetings held in Edinburgh. The meetings are quarterly and are held in the rooms of the Geological Society of London. In 1883 the Crystallological Society (also founded in 1876) amalgamated with the Mineralogical Society, bringing in as members such men as Story-Maskelyne, Sir Lazarus Fletcher, W. J. Lewis, and Sir Henry Miers. The journal of the society is *The Mineralogical Magazine*, to which has lately been added *Mineralogical Abstracts*. The first number of the magazine was issued in 1876, and from that date until the beginning of 1920, eighty-seven numbers, making eighteen volumes were issued at somewhat irregular intervals. Since 1920 quarterly numbers have been issued, with, in addition, separately-paged abstracts of a selection of the more important papers from other journals. The production of these abstracts has had a beneficial effect on the membership of the society, which now includes many mineralogists from other countries, especially the United States.

Sir Stamford Raffles (1781-1826), the distinguished British administrator in Malaya and founder of Singapore, appears to have had in mind for some years the establishment of a zoological collection in London, when in 1824 a meeting of 'friends of a proposed Zoological Society' met to appoint him chairman of an executive committee. Sir Humphry Davy, president of the Royal Society, is associated with him as joint founder of the Zoological Society, the object of which, as stated in 1825, was 'to attempt the introduction of new races of Quadrupeds, Birds, or Fishes, etc., applicable to purposes of utility, either in our farm yards, gardens, woods, waters, lakes, or rivers; and to connect with this object a grand zoological collection of preserved specimens.' Another circular issued later in the same year referred to the formation of 'a collection of living animals' to be 'established in the vicinity of the metropolis, together with a museum and a library, all to be accessible to the public. As it is impossible to attain all the objects of the society on its first establishment, those of utility will engage its earliest attention, and the more scientific views will be attended to as the means of the society admit.' In 1826 a grant of land in Regent's Park was received from the Government, and the society was formally constituted. The gardens were opened to the public on April 27, 1828. A year later the society received a Royal Charter. Of the far-famed gardens in Regent's Park it is neither possible nor necessary to attempt any description here. The library and offices adjacent to them date only from 1910, for from 1843 until that year the administrative centre of the society was in Hanover Square. The destiny of the museum collections falls for notice in Chapter IX. In 1931 the society laid the public under still further debt when it opened Whipsnade Park, a tract of nearly 500 acres, between Dunstable and Tring, lying high on the chalk slopes of the Chiltern Hills, thirty miles north-west of London. Here a number of suitable animals and birds already live, and many more will live in future, in the open air and under conditions as free from artificiality as possible. The society, through expert members of its staff and certain research Fellows, carries out researches in pathology, parasitology, anatomy, and various other departments of zoology, and among its publications special reference should be made to the *Zoological Record*, maintained since 1865, and to its *Scientific Proceedings* and *Transactions*, maintained respectively from 1830 and 1833.

Although the Entomological Society of London as at present constituted dates only from 1833, it is the lineal descendant of a series of more ephemeral societies 'during the first decades of the nineteenth century, such as the Aurelian Society, founded by Haworth in 1801, which appears to have become the Entomological Society of London in May, 1806, and lasted until at least 1822. Of these earlier societies the minute books are still extant, and many of them are in the possession of the present society.

The society was founded at a meeting held in the British Museum on 3 May, 1833, N. A. Vigors, M.P., being in the chair, and the first general meeting was held on 22 May at the Thatched House Tavern, St. James's Street. Shortly afterwards premises were rented for the meetings and for housing the library and collections at 17 Old Bond Street, and these were occupied till 1852 when a move was made to 12 Bedford Row. Here the society remained till 1875, with one brief interval in 1866, though from 1867 onwards the actual meetings were held in the rooms of the Linnean Society. In 1875 an attempt to affiliate with the Linnean Society was made, but the negotiations fell through and a move was made to 11 Chandos Street, the premises of the Medical Society of London. Here the society remained for nearly forty-six years and it was not until 1921 that it purchased the premises of its own at 41 Queen's Gate that it now occupies. To these it made an important addition in the form of a new meeting room in 1930. The society was incorporated by Royal Charter in 1885.

The society has published seventy-eight volumes of its *Transactions* and five volumes of its *Proceedings* to date. Prior to 1926 the *Proceedings* were published with the *Transactions*, but since that date they have formed a separate publication.

Within the same fertile period falls the foundation of the Ray Society (1844), which exists for the publication of works on natural history. It took its name appropriately from John Ray (1628–1705), the learned natural historian and publicist, son of a blacksmith, who made for himself a notable career as a teacher in the University of Cambridge, and afterwards as a traveller in western and southern Europe. The Ray Society had Professor Thomas Bell and Dr. George Johnstone as its first President and Secretary, and in its foundation Sir William Jardine was actively associated with them.

The British Ornithologists' Union was founded in 1858 by a small group of naturalists interested in bird life and the study of ornithology. Its purpose is the advancement of the study of birds from every point of view, and its funds and energies are primarily devoted to the publication of *The Ibis*, a quarterly journal of ornithology, which has appeared regularly since the date of the foundation of the Union and of which seventy-two volumes have now been completed. The first president of the Union was Colonel H. M. Drummond-Hay; the first secretary Professor Alfred Newton, F.R.S., and the first editor was Dr. P. L. Sclater, F.R.S., for many years secretary of the Zoological Society of London. Other well-known ornithologists among the original members were: F. D. Godman, J. H. Gurney, The Hon. J. L. Powys (afterwards Lord Lilford), Osbert Salvin and Canon H. B. Tristram. The election of members takes place twice a year at two general meetings held in March and October. There are no meetings for the reading of papers or scientific discussion, but a subsidiary body, the British Ornithologists' Club, has been formed for this purpose. Membership of this latter body is restricted to members of the Union. It meets once a month from October to June, and after a dinner, exhibitions and discussions on all questions relating to ornithology take place and the proceedings are published in the *Bulletin* of the British Ornithologists' Club.

In 1889 the Royal Society for the Protection of Birds was founded, and may claim to be the oldest of similar bodies now existing; it received a Royal Charter in 1904. Started modestly in Manchester by ladies averse from the ornamental use of birds' plumage, the society quickly attracted the attention of leading ornithologists. The centre of action was moved to London, and other aspects of bird protection were given place. The primary motive for the formation of the society was not local but international, as the birds of fine plumage it aimed at saving were killed all over the world, and the society soon threw out branches in South Australia and India which prepared for the legislation which followed. Its influence was felt in New Zealand through the sympathy of Sir George Grey, and representatives were also chosen in France, Belgium, and Germany, countries where national associations were formed later. The field of action was soon seen to be very large, but wild birds are now the one part of the wild life of Great Britain which has protection. Almost all the legislation on this subject has been initiated by the society. The protection of migratory birds requires international action, but an important step has been taken by the provision by the society of bird-nests at lighthouses on lines of migration. In 1920 investigations were begun into the danger to sea birds from the discharge of oil waste, and evidence was presented which was of weight in securing the legislation on the subject in 1922. The society has put into operation a successful scheme for the education of schoolboys and girls in a knowledge and love of birds. A quarterly journal is issued.

The Challenger Society was founded in January 1903 for the promotion of the study of 'oceanic zoology and botany,' later expanded to include oceanography in all its branches. The original members numbered fifteen, with Dr. G. H. Fowler as honorary secretary. The membership was at first limited to thirty, but this was subsequently increased, the society now consisting of five honorary and one hundred ordinary members. Four scientific meetings are held every year, generally in the rooms of the Royal Society, at which papers and exhibits of oceanographical interest are offered and discussed. Beginning in 1923 periodic joint meetings with representatives from the various marine laboratories have been held under the auspices of the Development Commissioners. Generally three such meetings take place in each year, two at one or other of the laboratories, and one in London.

The society publishes each year a brief report of its activities. In 1912 a handbook of practical oceanography entitled *Science of the Sea*, prepared by the society under the editorship of Dr. G. H. Fowler, was published, and a new edition, edited by Dr. E. J. Allen, F.R.S., was brought out in 1930. In 1907 the preparation of the society's *Bibliography of the Marine Fauna*, to cover the years 1758-1907, was begun under the editorship of Dr. L. A. Borradaile. The completion of this work was made possible by the generosity of the late Sir John Murray, but lack of funds has so far prevented its publication. A synopsis of the classification, however, with definitions of the geographical areas adopted, has been published by the society, and the index cards are stored at the British Museum (Natural History). Among other publications issued under the auspices of the society mention may be made of Dr. Fowler's *Charts: their Use and Meaning*, and a series of blank charts of the world, the polar regions, etc.

ENGINEERING

The Institution of Civil Engineers was founded in 1818 by eight young men who were impressed by the difficulty of gaining engineering knowledge at that time, to 'facilitate the acquirement of knowledge necessary in the civil engineering profession and for promoting mechanical philosophy.' Its inception marked the change of engineering from being the practice of a few craftsmen who, owing to their experience and personal qualifications, acted in an advisory capacity, to a profession. Most of the founders were engaged in the making of machinery, and their use of the expression 'civil engineering' marked the distinction still made between the civil and military sides of engineering. The papers read in the early years covered a wide field, and the society grew steadily in importance under Thomas Telford, the eminent engineer, who became its first president in 1820, and devoted himself to the work of the institution. He was followed at his death in 1835 by James Walker, and he by Sir John Rennie. The institution received a Royal Charter in 1828, and in 1838 moved to premises in Great George Street, Westminster, in which street, though not in the same building, it has been housed ever since. Its *Minutes of Proceedings* were first published in 1837, and cover the whole field of engineering science and practice. In its later years the institution has undertaken a number of special researches and investigations by means of committees, and it possesses a very complete library.

An important side of the work of the institution is the influence which it has exercised on training for the engineering profession. In 1867 a Student Class was formed, to enable young men who were undergoing training for the engineering profession to enjoy the advantages of the institution's meetings and publications. In 1889 proof of general education by means of examination was first insisted on for admission to that class, and in 1897 the institution established its own examinations in general and scientific subjects (partial exemption from which, however, can be gained by the possession of certain degrees and diplomas). The institution has laid down strict conditions as to the practical training and experience also requisite, and compliance with these requirements on the part of candidates for corporate membership is judged by the Council on testimony submitted. Much help was given to the examination work of the institution at its inception by Sir John Wolfe Barry, who was chairman of the examination committee for twenty years. Formerly the institution consisted of members (*i.e.*, civil engineers), associates (persons not necessarily all professional engineers), and honorary members. In 1878 the constitution was changed to its present form, under which the institution consists of members (civil engineers of standing in the profession), associate members (younger men educated and working as civil engineers), and honorary members; and attached to it there are classes of associates without corporate rights (men who work with engineers and have distinguished themselves in such pursuits as architecture, military engineering, railway management, contracting, etc.), and students. Much importance is attached by many public bodies employing engineers to the possession of qualifications corresponding to the standards set by the Institution. Corporate members are entitled to call themselves Chartered Civil Engineers. Regular meetings for the reading and discussion of papers and the delivery of lectures are held at the London headquarters and in local centres. The papers and discussions are published in the *Proceedings*; other papers not discussed are issued individually as

Selected Engineering Papers, and the Institution also publishes *Engineering Abstracts*.

The Institution of Mechanical Engineers was started in Birmingham in 1847, where its headquarters remained till 1877, when they were moved to London. Its first president was George Stephenson and it has grown to be the chief society in the world devoted to mechanical engineering, with an important technical library in its house at Storey's Gate, St. James's Park. It has been a pioneer in conducting numerous researches into problems of engineering. One of the chief objects of the institution, as set forth in its Royal Charter, is to co-operate with other educational bodies for the furtherance of engineering science and practice, and it holds its own examinations to test the general scientific and technical attainments of applicants for membership, who must also have adequate practical training. It also, in co-operation with the Board of Education and the corresponding bodies in Scotland and Northern Ireland, awards certificates and diplomas to students who pass successfully through courses of instruction in approved technical colleges and schools. Members and associate members are entitled to call themselves chartered mechanical engineers.

In the second half of the nineteenth century there were two engineering societies, the Society of Engineers (founded 1854) and the Civil and Mechanical Engineers Society (founded 1859). The first grew from the Putney Club, which began among the students of Putney College, one of the few places where, in those days, some scientific and technical engineering training was to be obtained. The second was started by pupils and draughtsmen of a marine engineering firm at Ratcliffe. In 1910 these two societies were united as the Society of Engineers. Meetings are held monthly and the papers read and published in the society's journal, which was a monthly publication till 1920 and is now issued quarterly; these papers are also published in the technical press, due acknowledgement being made, and the usefulness of the society is thus extended beyond its members. A gold medal and a number of premiums are awarded annually for papers. Apart from the work of the society in the furtherance of scientific knowledge, it has done much in the direction of regularising professional relationships and practice; it has an appointments register and a benevolent fund, gives legal advice to members, and is associated with a number of local engineering societies for the exchange of facilities. The fellowship of the society is awarded after examination, either those of the society or approved exempting examinations, except in the case of honorary fellows. The membership and associate membership are granted to those giving proof of qualification and experience without examination, and confer professional status. Members are engineers over twenty-five years of age who have had five years of responsible engineering work, and associate members are engineers over twenty-one years of age; associates include people engaged in allied professions, engineers under twenty-one years of age and engineering pupils over eighteen years of age.

The Institution of Naval Architects was founded in 1860 by Sir John Pakington and others. Meetings, etc., for 'practical and scientific subjects bearing upon the design and construction of ships and their means of propulsion.' It was incorporated by Royal Charter in 1910. The institution now comprises nearly 3,000 members, among whom are a large number of shipbuilders and marine engineers of other maritime countries. The annual meetings are held in London just before Easter, and the summer meetings at some of the shipbuilding centres in the United Kingdom or abroad. In recent years summer meetings have been held in France, Liverpool, London, Italy, Holland, and Belgium. An annual gold medal and premium are offered for the best papers submitted at the meetings by authors other than Members of Council. A number of scholarships are offered for competition annually in naval architecture and marine engineering; candidates being apprentices in the Royal dockyards or in private shipbuilding and marine engineering firms. The Council also award two postgraduate research scholarships in naval architecture, one given by the Royal Commissioners for the 1851 Exhibition and the other founded in memory of the late Sir William White. National certificates in naval architecture are awarded by a joint committee composed of representatives of the Institution, the Worshipful Company of Shipwrights, and the Board of Education (England and Scotland). The library of the institution consists of some 4,000 volumes, and also a valuable collection of books on shipbuilding and marine engineering (ancient and modern) left by the late Colonel C. C. Scott.

The Royal Aeronautical Society was founded in 1866 and is the oldest aeronautical institution with an unbroken record; it was made a Royal society in 1918 and was incorporated with the Institution of Aeronautical Engineers in 1927. It aims at the advancement of aeronautical science and engineering by means of conferring technical status on aeronautical engineers after examination, publishing papers and holding discussion, helping students, and providing an organisation for the study of aeronautics by those not professionally connected with aviation. It has several branches and awards a number of prizes, largely annually. In its early years the society encouraged investigation with what was then a little-known subject. Towards the end of the nineteenth century interest dropped and the society dwindled to a mere handful of members, but the rise of aviation led to its resuscitation. It was completely reorganised in 1911, and is now the most influential body of its kind in the world.

The Institution of Electrical Engineers was founded in 1871 as the Society of Telegraph Engineers, by a number of pioneers in the electrical world with Mr. C. W. (later Sir William) Siemens as first president. At first chiefly concerned with telegraphy, the society developed and broadened its scope with the developing applications of magnetism and electricity, as it was hoped when it was founded. The membership grew rapidly and includes practically every man prominently connected with electrical progress in this country and many from abroad, so that the institution has come to be recognised as the representative body for British electrical engineers. It was incorporated by Royal Charter in 1921. Meetings are held for the reading and discussion of papers, which are afterwards published in the monthly *Journal*, and committees draw up regulations on such subjects as the wiring of premises for lighting, heating, and power, and the electrical equipment of ships. There are also wireless and meter and instrument sections; local centres, subcentres, and students' sections in important cities in the United Kingdom, which hold regular meetings for reading papers; and two centres abroad. The important research work begun by the institution in 1912 is now carried on by the British Electrical and Allied Industries Research Association, five members of whose council are nominated by the institution, which also contributes to the Association's funds. In addition to the journal, *Science Abstracts* of the current literature of physics and electrical engineering are published in collaboration with the Physical Society of London and the American Physical Society. The institution has a large library (including those of Sir Francis Ronalds, an early member, and Professor Silvanus Thompson), and a lending library in addition, at its premises on the Victoria Embankment. This building previously belonged to the Examination Board of the Royal Colleges of Physicians and

Surgeons, and was bought by the Institution in 1910.

In 1888 some superintendent engineers and others associated with marine engineering in and near the Albert Dock formed a society, the Institute of Marine Engineers, to discuss their experiences and their bearing on the maintenance of steamships. One of the founders was Mr. J. Adamson, a superintendent engineer, who has worked untiringly for the institute ever since. Papers read at meetings are published in the *Transactions*, and at the early meetings much useful work in coal testing was carried out. Lectures and classes were also held for juniors, and visits to works and exhibitions of appliances arranged. Membership of the Institute is confined to engineers and ship-builders. Members must hold a first-class and associate-members a second-class sea-going certificate or must possess certain equivalent qualifications; companions are those engaged in commerce in connection with the ship-building industry. The Institute was incorporated in 1889, and bought its own premises in Stratford in 1893. In 1914 a new home was built by means of a fund raised for the purpose, near the Royal Mint.

The British Association of Refrigeration, at first the Cold Storage and Ice Association, was founded in 1900 to extend the use of refrigeration, to perfect the methods used, to advance the status of those engaged in the industry, and to encourage progress in the standard of administration. The transactions at its meetings are published in the *Proceedings*. The association has a branch in the Liverpool district and has affiliated to it two similar organisations in Australia, the National Federation of Cold Storage and Ice Trades. The Association is itself affiliated to the London Chamber of Commerce. It carries on propaganda work and organises lectures at schools, etc., and also interests itself in any question involving the interests of its members, such as the formation of the Food Investigation Board and the general advancement of food hygiene.

The Faraday Society, which exists to further the study of electro-chemistry, electro-metallurgy, chemical physics, and kindred subjects, was founded in 1903 and owes its inception and continuance largely to F. S. Spiers, who was honorary secretary from the formation of the society to his death in 1926. Sir Joseph Swan was the first president, and among subsequent holders of the office were Sir Oliver Lodge and Lord Kelvin, who were also members of the original council. Valuable transactions are published, at first three times yearly, then six, and now monthly. General discussions are held twice yearly, which are attended by workers from all parts of the world, and in which the society collaborates with other scientific bodies.

The Television Society was founded in 1928 as a sequel to demonstrations given at Leeds during the period of a meeting of the British Association in that city in 1927. The first president was Lord Haldane of Cloan. Since the formation of the society many notable developments have evolved in the transmission and reception of television signals, and a number of reports of successful receptions have been received from all parts of the country, also from Holland, France, and Germany. The society publishes its own *Proceedings*, containing original communications and technical contributions quarterly, and holds meetings monthly from October to May. Another activity of the society takes the form of an annual exhibition of instruments and apparatus representing developments in the science of television. A research committee has been formed in order to assist and organise the work of members, and a publications committee considers and advises upon matter for issue in the *Proceedings*.

METALLURGY, ETC.

The Iron and Steel Institute was founded in 1869 to afford communication between members of the iron and steel trades, and thus advance knowledge of practical and scientific subjects connected with iron and steel working and manufacture; and also to promote metallurgical education. Questions of commercial or trade interest, such as rates of wages, are excluded from discussion. The first president was the Duke of Devonshire, and the institute was incorporated by Royal Charter in 1899. Two general meetings are held annually, one in London and one in some important centre in the United Kingdom or abroad. Members must be employed in a practical or scientific capacity in iron and steel works, metallurgists, or persons specially interested in the application of iron and steel; there are a number of foreign members. Several prize funds are administered by the institute, and the Bessemer gold medal is awarded annually.

The Institution of Mining and Metallurgy was founded in 1892 and incorporated by Royal Charter in 1915. It represents the mining of minerals other than coal, and the production of metals other than iron and steel. It publishes annual *Transactions* and a monthly *Bulletin*. Qualification for admission to membership is based upon scientific training and technical experience. The institution works in the closest co-operation with the Institution of Mining Engineers (under a unified secretariat) which was founded in 1889, incorporated by Royal Charter in 1915, is a federation of seven provincial Institutes, and represents coal-mining engineering. The *Transactions* of the Institution of Mining Engineers are issued in monthly parts.

The two institutions are housed in Cleveland House, City Road, and their libraries are combined for the use of members of both institutions. To a limited extent books are sent out on loan to members, and the library service includes the supply of photographic reproductions of papers, excerpts, illustrations, etc., at a charge which covers the cost of materials used. Facilities are granted to companies and responsible persons who are not members of either institution, to consult the library. Members of the eight other kindred bodies (home and overseas) constituting the Empire Council of Mining and Metallurgical Institutions, also have access to the library on appropriate introduction. The office of the Empire Council is at Cleveland House.

The monthly *Bulletin* of the Institution of Mining and Metallurgy contains a classified index of current literature printed on one side only to enable members to keep up their own index cards under the various classifications.

The aims of the Institute of Metals are to afford a means of communication between members of the non-ferrous metal trades; to arrange periodical meetings for discussion of the practical and scientific aspects of these trades; and to advance the knowledge of metals and alloys. With these objects the institute was founded in 1908. There was already one national body devoted to the study of metals—namely, the Iron and Steel Institute; but this body confined its activities to the metallurgy of iron and its alloys, and so the new Institute was founded specifically to foster the interests of those engaged in the non-ferrous metal trades. Emphasis must be laid on the international nature of the Institute; of 2,200 members 800 are living overseas, and 300 of these are in the United States of America. Three general meetings are held every year, two in London and one in the provinces or abroad, and a *Journal*, containing reports of the work of members, is published annually, and supplemented by a monthly *Journal of Metallurgical Abstracts*. The institute has been responsible for various researches in metallurgy, notably those on the corrosion of non-ferrous metals; and it has organised an information bureau which is available for the public. Its headquarters are at 36 Victoria Street, Westminster, where there is a library for the use of members, containing the largest specialised collection of non-ferrous metallurgical works in the British Isles.

The Institution of Petroleum Technologists was founded by the late Sir Boverton Redwood in 1913 and incorporated in 1914. It was founded with the object of enabling technologists engaged in the petroleum industry to meet and correspond, to accumulate and disseminate trustworthy information regarding the occurrence and production of petroleum and oil shale, the conversion of the raw materials into their various manufactured products, and to elevate the professional status of all those engaged in the technical side of the industry. The membership, which is international, is made up of honorary members, members, associate members, students, and associates. At the headquarters of the institution there is a complete reference library dealing with all branches of petroleum technology; as far as facilities will permit the headquarters are available as a club, especially for members home from abroad and on visits to this country. The institution has branches in Roumania, Persia, Trinidad, and South Wales. The general meetings are held at the house of the Royal Society of Arts from October to May inclusive. A *Journal and Record of Transactions* which contains all papers read before the members, with their discussions, contributed papers and abstracts from current petroleum literature, is published monthly. The institution has also published *Standard Methods of*

Testing Petroleum and its Products. These tests have been accepted as the British Standard tests by the Government, public bodies, and all users and producers of petroleum and its products. A further revision is now under consideration.

The Institute of Fuel was formed as the result of the amalgamation of the Institution of Fuel Economy (founded in 1925) and the Institution of Fuel Technology (founded in 1927), two similar bodies of which the first limited its membership to qualified men and the second did not. Their amalgamation in 1927 as the Institute of Fuel was largely due to the influence of Sir Alfred Mond (afterwards Lord Melchett), who was president of them both. The members are divided into collective members (*i.e.*, firms and corporate bodies); fellows (*i.e.*, qualified fuel technologists, persons responsible for outstanding work in connection with fuel, and those who have given eminent service to the institute); ordinary members (*i.e.*, persons interested in the subject who wish to help on the work of the institute); and student members under twenty-five years of age. A medal and prize is awarded annually for the best paper written by a student. Meetings for the reading and discussion of papers, afterwards published in the journal of the institute, are held in London and provincial centres, and local centres were in course of formation in 1930. The aims of the institute are to solve the many problems connected with the use of fuel and power, and to co-ordinate research on the subject.

(*Note:—Reference to medical societies and institutes will be found in Chapter VIII.*)

CHAPTER IV

EDUCATION IN LONDON[1]

By T. L. HUMBERSTONE, B.SC.

'How can I write six-feet hexameters,' asks Sidonius in one of his letters, 'when surrounded by seven-feet barbarians?' The early history of London is a record of pillage, burnings, cruelties. Cæsar makes no mention of London and the inference is that in 54 B.C. London did not exist. In A.D. 61 Boadicea's hordes sacked the city and massacred those of its inhabitants who were left after the retirement of Suetonius, the Roman governor. Tacitus refers to London at that time as a place much frequented by merchants, a note often sounded in the history of London. A long period of silence and darkness followed. 'Schools in England,' says A. F. Leach, 'are coeval with the coming of Christianity'; and Christianity came not from the Celtic Britons nor from Gaul, but direct from Rome. St. Augustine landed in 597—with the Latin Service-book in one hand and the Latin primer in the other. In that year Ethelbert was baptized. Canterbury was Augustine's metropolis and there the first English grammar school was established. 'In 604,' says the Venerable Bede, 'Augustine, Archbishop of Britain, ordained two bishops, Mellitus and Justus, the first as bishop of the East Saxons with his See at St. Paul's, London, and the other as bishop at

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[1] In the early history of education in London, the author has quoted from his book *University Reform in London* (1926).

Rochester.’ A school was established in London as part of the episcopal establishment on the model of Canterbury. St. Paul’s School was undoubtedly, says A. F. Leach, the oldest as it was also the first in London. ‘There can be little doubt that it was originally founded as part of the cathedral in 604.’ Its history, however, was not continuous, for London underwent several lapses into paganism. But let us never forget that education came to England with Christianity. And let us be at least tolerant when we see the important place taken by the religious question in all educational discussions, including the foundation of new schools, colleges, and universities. If St. Paul’s School was ‘undoubtedly the oldest in London,’ by the same token the first text-book used in London was the Latin primer. Wholesome milk on which to suckle the citizens of no mean city, especially as improved by a great Londoner, William Lily (*c.* 1468-1522), the first High Master of St. Paul’s School, into that famous book *Lily’s Latin Grammar!* ‘Listen to me,’ says the clergyman-schoolmaster in George Borrow’s *Lavengro*, ‘there is but one good school book in the world—the one I use in my seminary . . . . I never yet knew a boy that was induced, either by fair means or foul, to learn Lily’s Latin Grammar by heart, who did not turn out a man provided he lived long enough.’ *Lily’s Latin Grammar* is not least of the debts which the world owes to London.

The First Schools

Fitzstephen, the biographer of Thomas Becket and London’s first chronicler, describes London of the twelfth century as 'the one principal seat of the Kingdom of England whose fame is spread abroad very far.' He praises her wholesome air, her Christian religion, her strength, her situation, and the chastity of her matrons. She was 'very pleasant also in her sports and pastimes, and replenished with honourable personages.' The official educational system of the city in those early days consisted of three schools attached to great churches, these schools being 'retained by privilege and ancient dignity.' But in addition, other schools, allowed 'by goodwill and sufferance,' were famous for their teachers of philosophy. Their scholars disputed for the sake of exercise, or for show, or for the pursuit of Truth, 'the grace of perfection,' or with rhetorical orations, speaking handsomely to persuade, observing the principles of art and omitting no matter contingent.

These three famous schools were St. Paul's, St. Mary-le-Bow, and St. Martin's the Great. As in other mediæval dioceses, the Bishop of London, acting through the Schoolmaster, afterwards called Chancellor, of St. Paul's, was the licensing authority for schools and teachers throughout London. St. Martin's was exempt from his jurisdiction as a collegiate church of canons, and St. Mary-le-Bow belonged to the Archbishop of Canterbury and was the seat of his ecclesiastical court, still flourishing as the Court of the Arches.

John Stow, born about 1525, gives a vivid account of the disputation of the scholars of the London schools in the churchyard of St. Bartholomew, the best of whom were given rewards. He mentions especially the master and scholars of the free schools of St. Paul's of London, St. Peter's of Westminster, of St. Thomas Acon Hospital, and St. Anthony's Hospital, 'whereof the last-named commonly presented the best scholars and had the prize in those days.' Later, in Elizabeth's reign, the scholars substituted blows for words. Stow relates in a famous passage 'the schollers of Paules meeting with them of St. Anthonies, would call them Anthonie pigs and they againe would call the other pigeons of Paules, because many pigeons were bred in Paules Church, and Saint Anthonie was always figured with a pig following him, and, mindfull of the former usage, did for a long season disorderly in the open streete provoke one another with *Salve tu quoque! placet tibi mecum disputare. Placet*. And so proceeding from this to questions in grammar, they usually fall from words to blows, with their satchels full of bookes, many times in great heaps that they troubled the streets and passengers; so that finally they were restrained, with the decay of St. Anthonies schole.' Strype in his edition of Stow a century later recounts how, in 1562, two hundred scholars from St. Anthony's would go nut-gathering, 'with streamers and flags and drum beating.'

The First Science Studied in London

What was the curriculum of these early schools? What was the first science taught or studied in London? Presumably the subjects of instruction were those of the mediæval monastic or cathedral school, originally the *trivium* of grammar, dialectic, and rhetoric, and as a later addition, the *quadrivium* of music, arithmetic, geometry, and astronomy. We have abundant evidence that boys were taught to argue. Can we infer that astronomy was the first science to be studied in London? The close association of the study of astronomy with the church persisted through the ages. 'The heavens declare the glory of God' and fix the date of Easter. Isaac Barrow, Gresham Professor of Geometry, studied mathematics at Cambridge in order that he might understand astronomy and so become a better theologian. There were astronomical heresies as the Italian philosopher, Giordano Bruno, burnt at the stake on February 17, 1600, discovered to his rue and ruin. Galileo's *Eppur si muove* was in direct contradiction to Holy Writ: *firmavit orbem terrae, qui non commovebitur;* 'He hath established the world, which shall not be moved.' Officially the heavens were perfect; the planets moved in perfect circles; the sun had no spots. We can find no evidence that London was interested in these speculations, London's martyrdoms to the cause of science having taken a different form. Its interest in astronomy was practical, arising through the applications of astronomy to navigation and the measurement of time. Sir Thomas Gresham in 1575 founded the first professorship in astronomy. The subjects of the five Regius professorships founded in 1546 by Henry VIII at Oxford and Cambridge, were divinity, Hebrew, Greek, civil law, and medicine, the chairs of astronomy at these universities being founded at a later date. As a school subject, astronomy lingered, especially in seminaries for young ladies, under the title 'use of the globes.' In the *Boarding*

School and London Masters' Directory, 1828, the list of 'professors in every department of education' is classified under subjects including writing, astronomy and the use of the globes, the classics, dancing, velvet-painting, and so on. To-day, astronomy, the science first professed in London, the queen of sciences, has attained a position of supreme interest. The stone which the builder selected has become a temple. Alas, few are allowed to worship there with full understanding.

In due course other sciences advanced their claims, including medicine or 'physic,' early adopted as a subject of study by the mediæval university. To the disciples of Galen we owe much of the early progress in scientific investigation.[1] Chemistry and alchymy were also recognised. Sir George Buck, in his appendix to Stow's *Annales or General Chronicle of England*, published in 1615, gives a list of the subjects in which instruction was offered in the city of London. Not only do we find the arts called liberal—such as one might expect to find at other seats of learning—but also most of the other arts and sciences 'proper and fit for ingenious and liberal persons.' First in the list is theology, 'the chiefest science, the science of sciences, and the key to all knowledge.' Languages 'holy, learned, and strange' were professed; also free and subtle arts, and an array of subjects which the educationalist of to-day might regard as frivolous—the art of dancing, for example, and the art of revels, and pyrotechny. The 'art gladiatore' or the noble art of self-defence, had its proper degrees and public trials. One learned to use the long sword, the rapier and dagger, the sword and buckler, the pike, the halberd, the longstaff, and other lethal weapons. Swimming and riding also formed part of the education of the English gentleman. Technical education? You could learn navigation and a science called cosmography, which had to do with the discovery of new worlds. Professional education? There was instruction in all branches of law, the common law, the law of conscience, civil law, and canon law; in physic and surgery; and in polemics, or art military. Pure art is represented by music and painting, and there are also such subjects as shorthand and—shades of Pelman!—'art memorative.' In London were to be found also very cunning architects, good chemists and alchymists, and odds and ends such as astrologers, antiquaries, philosophers, historians, and politicians. Our author gives details of the colleges, Inns of Court, and learned institutions in and near London, and claims for London not only the name and style of a university, but also a chief place in the catalogue of universities. It lacked only the Government and protection of an honourable Chancellor, an omission which the King, his master, could easily supply from a good choice of most grave and noble personages. The conclusion of his argument is worth quoting, and he adds after the word *finis*, as well as he may, *Laus Deo*.

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[1] Cf. Chap. VIII, *ad init.*

'Seeing then that there may be read, taught, studied, and professed so many arts, faculties, and sciences in this cittie of London, as in no Universitie more, and in fewe or none so manie. And that there be so many magnificent colledges, Athanaees, houses and schooles, founded and erected for them and their professors, and endowed with lands and revenewes by the auncient Kinges and Princes of this land, and by other noble and worthie Benefactors, and unto their royall priviledges indulted, who can then deny that London is not onely the third Universitie of England, but also to be preferred before many other Universities in Europe or in any other parte of the world knowne. *Laus Deo.*'

LONDON'S HISTORIC SCHOOLS

St. Paul's School as re-founded by John Colet, Dean of St. Paul's in 1509, was the child of the cathedral, born during the revival of learning, nursed by Erasmus. Colet was inspired by the liberal spirit of the Renaissance. Arraigned ecclesiastically for reading publicly the epistles of St. Paul, instead of the jargon of the schoolmen, he might have been burned 'if God had not turned the King's heart to the contrary.' Shadow of a coming event—the Reformation! By his statutes for St. Paul's School he declared that it shall be open to the 'children of all nations and countries indifferently,' a catholicity recalling the mediæval university. The number of children attending the school was to be one hundred and fifty-three, the number of fishes in St. Paul's miraculous draught. As to the curriculum, it passed his wit, he said, to devise and determine in particular, but he showed his love of Latin literature and his preference for Christian authors 'that wrote their wisdom with cleen and chaste Latin. I saye that fylthiness and all such abusion whiche the later blynde worlde brought in, whiche more rather be called *Blotterature* than *Literature*, I utterly abannyshe and exclude out of this Scole.' The High Master was to be learned in Latin, also in Greek 'if such could be gotten.' The most remarkable provision of the statutes was Colet's entrusting his school to the government of the Company of Mercers, men of 'probity and reputation.' When asked his reason he said, 'that there was no absolute certainty in human affairs; but for his part he found less corruption in such a body of citizens than in any other order or degree of mankind.' Edmund Halley (1656-1742), the astronomer, was educated at the school—he declared that before leaving school he had made observations on the magnetic needle.

Of the nine leading public schools of England, investigated in 1861 by the Clarendon Commission, London possessed four, Westminster and Charterhouse ranking as boarding schools and St. Paul's and Merchant Taylors as day schools. Charterhouse has since been removed to the country, and Merchant Taylors is soon to suffer the same fate. Westminster, founded by Queen Elizabeth in 1560, was traditionally a classical school, aiming at *multum non multa*, proud of its classical learning and untainted loyalty. A boy in the school publicly prayed for King Charles I 'but an hour or two before the monarch's head was struck'; but it is related that its famous headmaster, Dr. Busby, remained covered in the presence of his sovereign, Charles II, apologising by saying that the boys must not suppose that there were any greater in the realm than the headmaster of Westminster. Charterhouse, founded in 1611 by Thomas Sutton, was attended by Isaac Barrow, who was chiefly distinguished at school for fighting and setting the other boys to fight. It must have been one of the first public schools to teach chemistry, for in particulars of the school published in 1865 we read under the heading 'Drawing and Chemistry'—'The charge for these accomplishments is the same to all, namely for the former £5 5s. per annum; for the latter £2 2s.' Merchant Taylors, founded in 1561, is the outstanding example of a school established by a City Company. Its first high master, Richard Mulcaster, was a true Londoner. 'Rome I love but London better,' he wrote. His views on education were in advance of his day and generation, for he held that every boy and girl should be taught, at least, to read and write. Of the other famous old schools of London it must suffice to mention the Mercers' (1447), Christ's Hospital (1552), now removed to the country, Highgate School (1565), St. Olave's (1571), Dulwich College (1619).

SIR HUMPHREY GILBERT

Sir George Buck proves to the glory of God and his own satisfaction, that London at the beginning of the seventeenth century possessed all the educational resources of a great university, the substance without the form. A. F. Leach examines this claim in a special chapter in Sir Walter Besant's *Survey of London*. He explains that the *trivium* or trivial task of the twelfth-century schoolboy included rhetoric and dialectic, as well as grammar, and the three famous schools were merely the forerunners of the grammar schools of a later generation. He admits, however, that a university might have developed out of these schools and their philosophical rivals, as happened at Paris and possibly also at Oxford. 'But it was not to be.' The reasons he adduces may be quoted summarily. The hum of markets and wharves was too loud for the voice of learning to make itself heard. Paris was the political but not the commercial capital of France. The King's Court and King's Chancery, the main avenue to success for clerks, were not in the twelfth century settled in London. Learning was cosmopolitan. The centralising influence of the Roman Church tended to make Europe a single nation. Thomas Becket, one of London's most famous schoolboys, studied as a young man in Paris, and was there inoculated with the 'fool fury of the Seine' with disastrous results. It may be suggested as a further reason, that the spirit of London has always been practical, empirical, utilitarian if you will, and that the scholastic philosophy of the mediæval university would never have found there a natural home. Londoners, preoccupied in building the greatest city of the world, had no time or patience to discuss how many angels could stand on the point of a needle. Rabelais, not unfriendly to scientific research—were not his last words *je vais quérir un grand peut-être?*—mentions a dissertation in the library of St. Victor on the question 'whether a chimaera buzzing in a vacuum could devour second intentions.' Making fun of the whole system, he proposes the titles of a few imaginary theses, one of which has a curious twentieth-century ring: 'Whether the atoms, whirling to the sound of hermagoric harmony, could make a compaction or a dissolution of a quintessence by the subtraction of the Pythagorean numbers.' The nonsense of one age becomes the sense of another.

We see a reflection of London's attitude towards higher education in the scheme which Sir Humphrey Gilbert, navigator, one of the ablest and most gallant men of the Elizabethan age, submitted to Queen Elizabeth about the year 1570 for 'The erection of an Achademy in London for educacion of he Maiestes Wardes and others the youth of nobility and gentlemen.' He proposed that there should be schoolmasters and ushers to teach Latin and Greek grammar, Hebrew, logic and rhetoric, a reader of moral philosophy who should divide his readings between civil policy and martial policy—his reason for this being to break away from 'schole learninges,' for he agreed with Chaucer that 'the greatest clerks beth not the wisest men'; a reader in natural philosophy, two mathematicians, one of whom should deal with arithmetic, geometry, and matters of war, including the practice of artillery, assisted by one good horseman and a trained soldier, and the other should deal with cosmography and astronomy and navigation; a doctor of physic provided with a garden for growing simples who should treat both physic and surgery—the author was opposed to surgery being taught in barbers' shops, a most dangerous practice, especially in time of plague—a reader of civil law, another of divinity, teachers of French, Italian, Spanish, and

High Dutch, a master of defence, a teacher of music, a herald of arms, a librarian (the library to have copyright privileges), the whole presided over by a Rector. In universities, he urges, men study only 'schole learninges,' but in this academy 'they shall study matters of occasion meet for present practize, both of peace and warre.'

That scientific research was contemplated as proper work for the doctor of 'physic' is made clear. 'This phisition shall continually practize together with the naturall philosophor by the fire and otherwise, to search and try owt the secretes of nature, as many waies as they possiblie may.' They were to report annually to the Treasurer 'without equivocations or enigmaticall phrases.' 'For whose saffetyes I would wish the statute of the 5th of Henry IV touching multiplication to be dispensed at large' (a statute forbidding the search for the philosopher's stone). 'O noble prince,' he addresses Her Majesty, 'that gods shall blesse so farre as to be the onely meane of bringing this seely, frosen, Island into such everlasting honnour that all the nations of the World shall knowe and say, when the face of an English gentleman appeareth that he is eyther a sowldiour a philosopher or a gallant Cowrtier; wherby in glory your Majesty shall make your sellf second to no prince living.'

GRESHAM COLLEGE

To Sir Thomas Gresham, founder of Gresham College in the city of London, first great benefactor of higher education in London—greeting! Thomas Gresham, born in London of wealthy parents, was educated at Cambridge. It can be understood, therefore, that the college he conceived for London bore a resemblance to the mediæval university. God so blessed his industry, we are told, that he became the most wealthy citizen in England of his time, 'a jewell of trust, wit, and diligent endeavour,' as Sir Thomas Chaloner described him. At the close of 1574 or early in 1575, a few years after Sir Humphrey Gilbert had petitioned Queen Elizabeth to found a college in London, Gresham announced his intention of founding a college in London for the gratuitous instruction of all who chose to attend the lectures. His old university, Cambridge, tried to dissuade him, reminding him of a promise to present £500 to his *alma mater* either for the support of one of the old colleges or for the erection of a new college. Why, it was asked, should he wish to establish a rival university in London? But Gresham would not change his plans. His will dated July 5, 1575, gave his mansion in Bishopsgate to be used as a college after the death of Lady Gresham, and endowed seven professorships, *viz.*, in divinity, astronomy, music, geometry, law, physic, and rhetoric. Note the correspondences between these subjects and the mediæval *trivium* and *quadrivium*. The City Corporation and the Mercers' Company were appointed trustees under this part of the will. Foreseeing the possibility of default as to carrying out his wish, he threatened in his will the 'reproach and condemnation of the said corporations afore God.' The professors were to be unmarried—another reminder of the ancient universities—and were 'daily to read the said several lectures.' The endowment for the college, in addition to the use of the mansion, was provided by the rents of the Royal Exchange, established by Gresham in 1566. Gresham died on November 21, 1579, and was buried in St. Helen's, Bishopsgate, with great pomp. The first lectures under his endowment were given in 1597, and the stipend of the professors was fixed at £50, rather larger than that of the regius professors at Oxford and Cambridge. The college contained residential quarters for the professors, an observatory, a reading hall, and some almshouses. In the morning the lectures were delivered in Latin, and in the afternoon in English. Henry Briggs (1561-1631) was the first professor of geometry; he calculated complete tables of logarithms and introduced decimal fractions. The list of professors also includes John Greaves (1602-1652) the earliest scientific metrologist; Isaac Barrow (1630-1677), who resigned his chair at Cambridge in favour of his pupil, Isaac Newton; and Christopher Wren (1632-1723), astronomer, mathematician, and architect.

The administration of the college soon became the subject of controversy. Why, it was asked, were the lectures not read daily as provided in the will, instead of during term only? And why were the lectures read in Latin, English in England being best understood? A petition was presented by divers citizens, but without result, the professors pleading prescription. An anonymous tract entitled *Sir Thomas His Ghost* and published in 1647 indicts the professors on these counts and goes so far as to suggest in doggerel verse—

'Not love of learning, or to make
Their country skilfull artists, but the sake
Of money them compels . . . . .'

and the introduction, addressed to the impartial reader, suggests that 'they have their meanes for a song.' The ineffectiveness of the college must have had a depressing effect on educational reformers. Dr. F. J. C. Hearnshaw in his *Centenary History of King's College* blames the lack of a 'common government' or 'the protection of an honourable chancellor' to which our good friend Sir George Buck alludes. 'The professors,' he says, 'in the absence of a disciplinary and co-ordinating authority, became (according to the habit of their species) apathetic in their duties and antipathetic towards one another. Their chairs degenerated into beds, and their activities declined into chronic lethargy. Only by their regularity in receiving their salaries and by the spasmodic energy of their periodical quarrels did they display evidence of their continued existence.' The quarrels of the professors at times caused amusement to the citizens of London. It is related, for instance, that Dr. Mead with drawn sword on one occasion obtained the advantage over Dr. Ward. 'Beg for your life!' 'No, Doctor,' was the reply, 'that I will not till I am your patient.' Dr. Johnson suggested that the professors instead of lecturing gratis, should be allowed to charge a small fee, say sixpence, and so have an incentive to obtaining an audience for their discourses.

At Gresham College the Royal Society originated in 1645, as detailed elsewhere in this volume, and met there (with interruptions) until 1710. When the society found new quarters they took their library with them, to the great inconvenience of the Gresham professors. In 1767 the old mansion was sold to the Government for a beggarly £500 for use as an excise office. The lectures were delivered in the Royal Exchange until, in 1841, the present college was erected at the corner of Gresham and Basinghall streets; and there lectures in the subjects prescribed by Gresham's will are still delivered by the Gresham professors.

FRANCIS BACON

Sir Thomas Gresham was connected by marriage with the Bacons, and may have discussed with Francis Bacon the problems of London education. If so, agreement was presumably not reached, for it has been said of Bacon's *New Atlantis* by Dr. Alfred B. Gough, one of its numerous editors, that the book is 'a protest against the schoolmen with their barren speculations and the charlatans, alchemists, astrologers, quacks, and the like, with their empirical gropings.' Francis Bacon must have nursed for many years his conception of a great Institute or College of Scientific Research. In *Gesta Grayorum*, the Christmas revel, written for Gray's Inn in 1594, he appeals to a mock sovereign to collect a most perfect and general library, to provide a spacious and wonderful garden and a goodly huge cabinet, and a still-house furnished with mills, instruments, furnaces, and vessels. This was not an idle speculation; he was eager 'to set the machine to work,' and laid about to find a suitable place in the ancient public schools and universities. His ideas are elaborated in the book, *New Atlantis*, which he left in manuscript unfinished—'the rest was not Perfected' are its last sad words. He died on April 9, 1626, performing a scientific experiment on refrigeration,[1] aged 63, a natural natural-philosopher, caught up by worldly ambitions, politically broken and disgraced.

New Atlantis describes a wonderful institution entitled Solomon's House, the noblest foundation that was ever upon the Earth, the 'Lanthorne of this Kingdome,' dedicated to the works and study of the creatures of God. Its end was 'the Knowledge of Causes and Secrett Motions of Things; and the Enlarging of the bounds of Human Empire to the Effecting of all Things possible.' The staff included merchants of light, depredators, mystery-men, pioneers, compilers, dowry-men or benefactors, lamps, inoculators, interpreters of nature, novices, and apprentices. Bacon sees in a clairvoyant vision the wonderful scientific discoveries of a later age. They are all there, the now familiar faces—the phonograph, microphone, aeroplane, submarine, synthetic perfumes, high explosives, artificial gems, weather forecasts, microscopical diagnosis, inhalation of gas. Marvellous man! Well do you deserve the statue in your well-loved Inn, the garden of which you planted. We know that you wrote the essay on gardens beginning 'God Almighty first planted a garden; and indeed it is the purest of human pleasures. It is the greatest refreshment of the spirit of man, without which buildings and palaces are but gross handiwork.' Did you, peradventure, as some think, write Shakespeare's plays as *parerga*?

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[1] Chap. I, p. 20.

Bacon's seed for a Solomon's house did not fall on wholly barren ground. Sir William Petty was inspired to propose in 1648 the foundation of an institution for scientific research and teaching; and Abraham Cowley wrote, probably in 1658, and published in 1661, a proposition for the advancement of experimental philosophy, a 'philosphical college' near London, a practicable proposition, as Bishop Sprat, historian of the Royal Society, admitted, subject to reservations on account of finance and the expediency of combining teaching and research in the same institution. John Evelyn, the diarist, also proposed in a letter to Robert Boyle, the great chemist, that a scientific college should be established. But in the result it was a society—the Royal Society—and not a 'House' which was created, a society of which Petty, Cowley, and Evelyn, were original members; and some of the founders of that great academy, John Wallis, the mathematician, and Robert Boyle, the chemist, acknowledged Bacon as the originator of their plan. But the 'House' is not yet perfected.

THE EIGHTEENTH CENTURY

The seventeenth century is resplendent in the history of English science on account of the foundation of the Royal Society. There is little to record, however, in either the seventeenth or the eighteenth century in the development of higher education in London. Inertia extended beyond the capital city. The Royal Commission on Oxford and Cambridge Universities (1922) says: 'It would be unfair to Oxford and Cambridge to condemn them for their lethargy, corruption, and sinecurism in the mid-eighteenth century, without comparing them with the House of Commons, the municipal corporations, the public offices, the services, and the Church of the same period. In an age of great individual genius and enterprise, all old-established institutions were more or less corrupt or lethargic.' Daniel Defoe in a pamphlet entitled *Augusta Triumphans*, or the way to make London the most flourishing city in the universe, published at one shilling in 1728, opens with a proposal for 'an University where Gentlemen can have academical Education under the eye of their Friends.' The author had 'but a short time to live'—he died in 1731 and his bicentenary has been celebrated this year—'but of all his reflections none was more constantly his companion than a deep sorrow for the present decay of learning among us, and manifest Corruption of Learning.' 'Oxford and Cambridge abounded with Sharping Jilts.' 'Why should such a Metropolis as London be without an University? . . . . . Will not London become the Scene of Science?' 'In a word,' he says, 'an Academical Education is so much wanted in London that every Body of Ability and Figure will readily come into it.' The expense would be small as the sole charge would be the hire of a convenient hall or house, which might be called a college, suitable for the pupils to live or diet. But he goes on to say London is so extensive, its university might be composed of many colleges quartered at convenient distances—an intelligent anticipation. Gresham College smelt too much of *Sine Cure*. As an afterthought he suggests that colleges could be joined to existing schools such as Westminster and

St. Paul's, and finally it occurs to him that the students ought to be able to keep their books at the college 'for 'twould be most inconvenient to lug them backwards and forwards,' and should also dine in commons or at least near the college.

For the rest, Maitland's account in his *A History of London* (1739) of the 'Learning and Charities' of London includes particulars of 'divers philosophical Lectures read in the several parts of the City and Suburbs by men of great Learning, Knowledge and Experience, who at a small charge explain and demonstrate to their Auditors the following doctrines in experimental philosophy and improvement.' A formidable list follows, including the laws of motion, hydrostatics, pneumatics, and optics, the last specifying 'the circulation of the Blood and other curious objects shewn by Microscope,' and also the 'The Explanation of the Majick Lanthorn.' One of these men 'of great Learning, Knowledge, and Experience,' Mr. Tatum at 52 Dorset Street, Fleet Street, builded better than he knew, for his lectures were attended by Michael Faraday, at a charge of one shilling a lecture.

The education of the poor received attention from the Society for Promoting Christian Knowledge, chartered in 1701 with the great object 'to further and promote that good design of erecting Catechical schools in each parish in or about London.' The movement had a strong religious bias. A charity school was a 'fortress and a frontier garrison against popery.' The children were taught 'civility and good manners and reading and catechizing,' and in some the boys learned writing and arithmetic and navigation. If the curriculum was fairly liberal, there was no guarantee of the competence of the teachers. Mandeville referred to them as 'wretches of both sexes.' But the main objection to the system in later times arose from its pauperising character. The poor, it was said, became accustomed to the burden of favours heaped upon them by the rich and learned to stoop that the load might be increased. The children wore a special uniform and were continually reminded in charity sermons of the obligations they were under to the rich; at public dinners they were paraded round the room and indulged in a glass of wine to drink the health of their benefactors.

PUBLIC EDUCATION

London was the scene of Joseph Lancaster's efforts towards national education. In 1798, at the age of eighteen, he set up a school for the poor in St. George's Fields, afterwards in the Borough Road. Starting with nearly a hundred pupils, their number increased in a short time to a thousand, a number which could only be coped with by the ingenious monitorial system which set children to teach children; the cost was only a few shillings per child per annum. Lancaster's work was commended by King George III, who expressed his wish 'that every poor child in my dominions should be taught to read the Bible,' and offered to subscribe £100 annually to this great object. Several generous friends, who were also 'Friends,' came to the assistance of Lancaster in his financial difficulties. At a meeting of Lancaster with William Corston eloquent tribute to the Bible, the 'book that has been woven into the life of all that is noblest and best in English history.' It was the comprehensiveness of the London School Board, their ambition to provide a system of schools not restricted to 'elementary education' as defined by law, which led to their undoing. The famous Cockerton decision declaring illegal certain work of the London School Board forced the Government to face the problem of education in its broader aspects and to pass, first the Education Act, 1902, and a year later the special Act for London abolishing the school board and transferring its work, with much wider terms of reference, to the London County Council. That Council had already been 'blooded' for educational work, if the term may be used, through the Technical Instruction Act of 1889 and the 'whiskey-money' grant a year later. We are reluctant to drag statistics from their natural *habitat* in tables and curves, but a few may be given to illustrate the magnitude of the educational work of the London County Council. In 1929 the Council had 918 elementary schools and 77 central schools in their charge, with 17,401 teachers and an average attendance of 541,888 children; 27 maintained and 52 aided secondary schools, with a total of 15,857 boys and 15,430 girls.

In the earliest days of the London School Board, Huxley had pleaded for an arrangement 'by which a passage could be secured for children of superior ability to schools in which they could obtain a higher instruction than in the ordinary ones. He believed that no educational system in this country could be worthy the name of a national system or fulfil the great objects of education, unless it was one which established a great educational ladder . . . . . ' There is to-day in London a complete system of promotion by means of scholarships from one grade of school to another and to the universities.

BIRKBECK COLLEGE

Popular interest in education at the beginning of the nineteenth century extended beyond the poor to the 'mechanic.' Dr. C. Delisle Burns in *A Short History of Birkbeck College* (1924) gives an account of the foundation of the London Mechanics' Institution, now Birkbeck College. The original idea hailed from Glasgow where Dr. George Birkbeck (1776-1841) had lived and taught as professor of natural philosophy in the Andersonian University. What nobler object than to make working men acquainted 'with the facts of chemistry and of mechanical philosophy and of the science of the creation and distribution of wealth,' subjects at that time neglected in our ancient universities? Opposition came from those who mistrusted the idea of educating working men; it was adapted, one writer suggested, 'for the destruction of the empire'; the founders were 'scattering the seeds of evil.' The institution had a struggle for existence. Financial difficulties were serious; the interest of working men tended to wane; and there was an intellectual antagonism coming from men such as Carlyle, who thought that the progress of science would destroy mystery. Brougham, one of the champions of the new movement, was derided as the 'learned friend' with his 'March of Mind.' But the mechanics' institutions in 1824 and the immediately succeeding years, their historian proudly declares 'were far in advance of the universities of Oxford and Cambridge in regard to the physical sciences.' In 1866 the name of the London Mechanics' Institution was changed to The Birkbeck Literary and Scientific Institution. The new Charter of the University of London of 1858 made it possible for the institution to prepare students for university degrees, and this side of the work developed until the institution, renamed the Birkbeck College, was admitted as a school of the university in 1920. The governing body of the college includes representatives of the students, an unusual feature in college constitutions for which the students of Birkbeck College have consistently fought.

We have seen that from the foundation of Birkbeck College importance was attached to chemistry. Bernard H. Becker in *Scientific London* (1874) gives a view of the teaching of chemistry in an apartment which, were it not devoted to the use of science, he would not hesitate to designate the back kitchen. A couple of glaring 'butcher's lights' illuminate a rough deal table from behind which Mr. Chaloner expounds the properties of carbonic acid gas. 'The lecturer and the audience evidently mean business.' And now for the sequel. Among Chaloner's pupils was Sidney Gilchrist Thomas (1850-1885) clerk of the Marlborough Street Police Court, who from about 1870 dedicated his life to the solution of one special problem, the elimination of phosphorus in iron smelting. His biographer in the *Dictionary of National Biography* says, 'A sentence used by Mr. Chaloner, teacher of chemistry at the Birkbeck

Institution, in the course of a lecture which Thomas heard, seems to have imprinted itself deeply on Thomas's mind: "The man who eliminates phosphorus by means of the Bessemer converter will make his fortune." ' From 1860 onwards, Sir Henry Bessemer and an army of experimentalists had vainly grappled with the difficulty. The problem was of great economic importance, for its solution would make the phosphoric iron ores of Britain, France, Germany, and Belgium available for the production of iron and steel. Thomas solved the problem and made the prophesied fortune. It was spent in philanthropic objects after his early death, for his biographer says 'he held "advanced" political and social views and had he lived he had intended to devote his fortune to the alleviation of the lives of the workers.' Well might Gladstone write an article about him entitled 'A rare young man.'

THOMAS CAMPBELL

The first overt event in connection with the foundation of the University of London was the publication in *The Times* on February 9, 1825, of Thomas Campbell's open letter addressed to Henry Brougham. After returning thanks to 'my dear Brougham' for his practical observations on the education of the people and for his services to society, Campbell develops his own views on the education of the working classes and of the 'middling rich,' especially the employers of labour. The education of the working classes was already a 'triumphant cause.' But as to the 'middling rich' it was desirable and practicable that intellectual accomplishments should be more widely diffused even if there were no way of making heads as capacious as purses. But to say that more knowledge was desirable was not to deny that much already existed. 'There is a universal quickness and activity in the English metropolitan mind, joined to the indigenous humanity of English character,' and our capital contained a greater number of well-informed citizens than any capital in the world. Campbell's main thesis was that knowledge had increased and would increase among the poor and that it was desirable that the knowledge of the rich should increase in proportion. But the keepers of 'finishing academies' need feel no alarm. 'My project, if adopted, would do them good, and would bring them more pupils to prepare for a new university.' He proceeds to unfold his great plan. 'The plan which I suggest is a great university. Not a place for lecturing to people of both sexes (except as an appendage to the establishment), but for effectively and multifariously teaching, examining, exercising, and rewarding with honours in the liberal arts and sciences, the youth of our middling rich people, between the ages of 15 or 16 and 20, or later, if you please,'—a place worthy of 'our gigantic metropolis' and suited to the circumstances of the times and deserving to be called a university. As to the allegation that the health and morals of youth would suffer by an education in London, he considered that to quote the young men of the metropolis as an infirm race would be an utter absurdity. Of their morals he spoke with less assurance; but as to their health, the youths could study five days a week and 'a whole holyday on Sunday, and a ramble into the country, methinks, would recruit them quite as well as if they were sent to Cambridge itself to recruit their appetite for food and virtue.' The Germans had at one time a strong prejudice against the existence of a university in a capital town, but they now found the students of Berlin and Vienna were the most regular-living youths in all Germany. He estimated the cost 'to build and endow a London University' at £100,000, which could be raised by 2,000 families subscribing £50 each. Revive the fashion of wearing full-bottomed periwigs costing £50 each, and £100,000 would at once leap from the pockets of the middling gentility, in order to save caste. Happily the fashion of the day was to decorate the inside more than the outside of the skull. The university should be placed 'centrically.' Assuming a youth could walk two miles, you would have a circle of population four miles wide. The cost of Oxford and Cambridge—which he estimates at £250—was out of the question with a large number of families. His proposal was no matter of party politics or Church-and-State disputation. It was a point of union for all the friends of liberal views. As the prophet Isaiah said: 'The liberal deviseth liberal things, and by liberal things shall he stand.'

The short leading article on the proposal published in *The Times* on the same day was not altogether encouraging. It was admitted that a proposal emanating from the author of *The Pleasures of Hope*, and addressed to a 'distinguished individual' commanded considerable attention; but independent of the interest attaching to the writer of the letter and its recipient, there was very little in the letter itself worthy of public attention. As a statement of a great plan, it was 'crude in conception and meagre in development,' and the want of precision suggested that the writer had a very imperfect idea of his own project. 'There is also a levity in the style, which, added to its want of distinction, makes the epistle unworthy both of the subject and of the writer.' But the 'proposal of a Metropolitan University' was not condemned *per se*, 'We say nothing here of the merits of the scheme itself. because we repeat we do not clearly see what it is.'

UNIVERSITY OF LONDON

It is most gratifying to London and a tribute to the difficulty of its educational problems that these problems have attracted the attention of Lord Chancellors of England. Willingly have they run the risk of being called philosophers among lawyers and lawyers among philosophers. To Francis Bacon we have already paid ' the meed of some melodious tear' and to Lord Haldane grateful homage will soon be offered. Brougham, destined in a few years to become Lord Chancellor, associated himself with the formation of an association entitled 'The Proprietors of the University of London,' which acquired 'a piece of land near Gower Street, in the parish of St. Pancras, in the County of Middlesex,' for the erection of a building to be called 'The University of London.' As Dr. Waller observes, the University of London was the intellectual expression of the Reform period. It sought to provide for the educational needs of non-members of the Church of

England who were excluded from the ancient universities. It originated, he says, 'as a combination between Scotch lawyers, English philosophers and philanthropists, Jewish financiers and Dissenters of all complexions, and as an instrument of attack upon Tory privilege, it enjoyed the patronage of the Whig nobility.'

Students of the educational history of the early years of the nineteenth century, with its embittered battles between Church and undenominationalism for the control of the elementary schools, and its memories of Lancaster, Bell, and the redoubtable Mrs. Trimmer, will not be surprised that the 'godless college' in Gower Street was not left in full possession of the field of higher education and with the sole obligation to afford 'the young men in the cities of London and Westminster adequate opportunities for obtaining Literary and Scientific Education at a moderate expense.' On June 21, 1828, the Duke of Wellington presided at a meeting at the Freemasons Tavern, supported by the Archbishops of Canterbury and of York, and by thirty bishops, at which it was decided to establish in the metropolis another college for general education. An essential part of its system of education was to be 'to imbue the minds of youth with a knowledge of the doctrines and duties of Christianity as inculcated by the United Church of England and Ireland.' Thus arose King's College, London, which was granted a Royal Charter of Incorporation on August 14, 1829, and the lease of the site on the eastern side of Somerset House belonging to the Government which the college still occupies.

Within a space of two years London was provided with two rival colleges, based on different principles, the free college of the dissenting and Whig parties, and the privileged college of the Tory party. The older college was destined to wait until 1836 before receiving its Charter of Incorporation with the title London University College. Neither college was given the privilege of granting degrees. For this work—to grant academical degrees to pupils of the two teaching colleges without the imposition of any religious test—an entirely new institution—The University of London—was founded by Royal Charter of November 28, 1836, another charter being granted on the same day to University College.

The first Senate of the University of London included, as would be expected, two 'Right Reverend Fathers in God,' the Bishops of Durham and Chichester. Dr. Arnold of Rugby was one of the few members who might be deemed to represent the Arts faculty, but his service was brief owing to doctrinal difficulties. Law and Medicine are strongly represented. The outstanding scientific names in the list are John Dalton and Michael Faraday. Faraday, who 'could not afford to get rich,' gave ungrudging service to the university for twenty-seven years, and shaped its policy in the matter of degrees in science. The university was the first to establish special degrees in science. Its re-constitution in 1900 as a teaching university was mainly due to men of science, led by Huxley, Roscoe, and others; and the first principal of the reconstituted university was Sir Arthur Rücker, the physicist.

UNIVERSITY COLLEGE

The deed of settlement of the 'University of London,' afterwards 'University College,' dated February 11, 1826, stated that 'the object of the said Institution is the advancement of Literature and Science, by affording to young men residing in or resorting to the cities of London and Westminster, the Borough of Southwark and counties adjoining either of the said Cities, or to the said Borough, adequate opportunities for acquiring Literary and Scientific Education at a moderate expense,' and a fundamental principle adopted by the founders was that of complete impartiality among differing religious beliefs. 'The department of Chemistry,' said Professor Norman Collie in his centenary address (June 8, 1927), 'has from the foundation, played a prominent part in the development of the science of Chemistry. The laboratory was one of the first open to students for practical work; its professors men who have left an abiding impression on their science.' Originally, two professorships of chemistry were contemplated, one for pure chemistry and one for applied chemistry or 'the application of chemistry to the arts.'

Dr. Edward Turner, the first professor of chemistry, was succeeded by the more famous Thomas Graham, who had many distinguished students, including Henry Roscoe. An additional professor for practical chemistry was appointed in 1845, Edward Fownes, succeeded by A. W. Williamson, famous for his work on 'etherification.' Williamson, on Graham's resignation in 1854, held both posts, and was succeeded in 1887 by William

Ramsay, with whose great work as a scientific discoverer the college will always be honourably associated, including the discovery of argon, neon, krypton, and xenon in the atmosphere and the isolation of helium. Referring to the scientific research workers at University College, Professor Collie says: 'Their researches touched on all the chief branches of chemistry, inorganic, organic, and physical, while the discoveries which resulted from their researches were of fundamental importance in the development of chemical science.' Ramsay's memorial at the college takes the form of the Ramsay Laboratory of Chemical Engineering and the physico-chemical laboratories. The work of the college in physiology described by Professor E. H. Starling in his address 'A Century of Physiology' (February 28, 1927), is almost as famous as its work on chemistry. It is associated with the names Sharpey and his pupils, Michael Foster, Burdon-Sanderson and Schafer. The physiological subjects investigated at University College include the heart, electro-cardiography, physiological action of ions, visceral nervous system, central nervous system, hormones and vitamins. Many brilliant researchers in physiologists have worked at University College. Dr. Starling stated that 'about forty men and women are constantly engaged in research in the physiological and biochemical laboratories.' University College has also been a pioneer in medical and engineering education, but the professional medical work is now carried on at University College Hospital Medical School, separately organised.

The Rev. Dr. Dionysus Lardner was the

first professor of natural philosophy. J. J. Sylvester, the brilliant mathematician, was one of his successors. The department of botany is associated with the honoured name of John Lindley, who occupied the chair till 1860. 'If Botany or any other science,' he said in his inaugural lecture, 'cannot be taught upon philosophical principles, it can neither be taught, nor is it worthy of being learned upon those which are empirical. At all events we will here make the experiment.'

King's College

King's College was founded in 1828 as a college in which practical instruction in the useful sciences and arts shall be combined with sound edification in the doctrines and duties of Christianity as taught by the United Church of England and Ireland. The 'regular' course of education consisted of classics, mathematics, and English literature and history, for which professors were originally appointed with guaranteed salaries, and it was proposed to appoint eight other professors remunerated by a portion of their students' fees, the scientific subjects included in the list being chemistry, natural and experimental philosophy, natural history and zoology (one chair), anatomy and physiology (one chair), theory and practice of medicine, surgery. To this list, botany and geology were afterwards added. John Frederic Daniell, inventor of the Daniell cell, was the first professor of chemistry. Sir Charles Lyell the distinguished geologist, was the first professor of geology. He only retained the chair for two years, for, as Professor F. J. C. Hearnshaw, the historian of the college ominously remarks, his writings were 'a direct challenge to Ussher's chronology,' and 'made havoc of the accepted cosmogony of current orthodoxy.' The religious character of the college and its tests for teachers (abolished in 1903) must have cramped its scientific work. We read, for instance, that Sir Benjamin Brodie and the college professors wished to see Liebig, the famous German chemist, appointed as Daniell's successor, but that Bishop Blomfield and Archbishop Howley refused to sanction the appointment of a Lutheran. W. A. Miller succeeded Daniell in 1845. Charles Wheatstone, appointed in 1834, was the first professor of experimental philosophy. The council allowed him £50 for apparatus, and in 1836 approved of his 'laying down a series of iron and copper wires in the vaults of the college for the purpose of trying some experiments in electricity on account and at the expense of the Royal Society.' Are there many earlier references to the electric telegraph, Dr. Hearnshaw asks? Clerk Maxwell became Professor of Natural Philosophy in 1860, 'undoubtedly,' says Dr. Hearnshaw, 'one of the most distinguished of all the great men associated with King's College'; but early in 1865, in consequence of disciplinary troubles, it was intimated to him that he should resign, and he was released for more epoch-making work. King's College was a pioneer in engineering education, establishing a 'department of engineering' in 1831. With the advent of public grants for technical education, the scientific work of the college developed rapidly. 'In 1898,' says Dr. Hearnshaw, 'small results gave large satisfaction in the faculty of science.' New laboratories were opened by Lord Lister in 1900, and shortly afterwards it became necessary to provide fresh accommodation for experimental psychology, for chemistry, for physics, and for zoology.

ROYAL COLLEGE OF CHEMISTRY

About the year 1842 Dr. John Gardner, assisted by Mr. J. Lloyd Bullock, brought forward a scheme for establishing in London a practical school of chemistry upon the model of that at Giessen. The first name proposed was the 'Davy College of Practical Chemistry' as a memorial to the great English chemist. A provisional committee, including some well-known names, was formed, and a prospectus issued asking for subscriptions. The college, the prospectus stated, 'will be mainly devoted to *Pure Science;* at the same time, to meet the exigencies of this country, and to adopt the latest improvement in the continental schools, an appendage will be provided, devoted to the Economic Arts, where enquiries relating to Pharmacy, Agriculture, and other Arts may be pursued.' At first the promoters entered into negotiations with the Royal Institution with the view of finding accommodation in that Institution, but these negotiations failed owing to want of space. An enlarged council for the new college held its first meeting on January 14, 1845, and started a more intensive propaganda, issuing numerous papers including one 'On the Claims of Chemistry on the Benevolent,' and another 'On the bearing of Chemistry upon Metallurgy and Mining,' and another addressed 'To Agriculturalists' who were invited to see a panacea for the prevailing agricultural depression. At last, on July 25, 1845, definite form was given to the proposed college at a further meeting, a council was elected and the Prince Consort consented to be named president. August Wilhelm von Hofmann (1818-92), at that time *privat docent* at Bonn, accepted the appointment of professor, and in the following October temporary laboratories were fitted up in George Street, Hanover Square. Within a week twenty-six students were enrolled, including de la Rue, Abel, Nicholson, How, Rowney, Bloxam, and Galloway, all afterwards distinguished. The Queen gave her consent to the title of the Royal College of Chemistry. A special building with a frontage on Oxford Street was soon provided, accommodating forty students. Two volumes, published in 1849 and 1853, contained reports of the researches conducted in the college under Hofmann's inspiring direction. Financial difficulties arose, partially countered by Hofmann's giving up his official residence, exercising the strictest economy, undertaking the duties of secretary, and later accepting a reduced salary. A danger of overlapping arose with the new School of Mines,[1] established by the Government in 1851 with a chemical laboratory under Dr. Lyon Playfair, and the Council in 1853 made an offer to the Government to take over the College, an offer described in the letter of provisional acceptance 'as being highly liberal on the part of the Royal College of Chemistry, and very advantageous to the public.' The transfer was carried out with effect, and from October, 1853, the college became a department of the Metropolitan School of Science.

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[1] Cf. Chap. IV, p. 173.

In 1863 Hofmann returned to Germany to organise a chemical institution on a great scale in the University of Bonn; and in the following year was elected Professor of Chemistry at Berlin. He was succeeded at the College by Dr. Edward Frankland. The college retained its distinctive name until 1872, when it was removed to South Kensington, becoming merged into the institutions known later as the Royal College of Science and Royal School of Mines. The most famous student of the Royal College of Chemistry was William Henry Perkin, who joined the college in 1853 and became honorary assistant to Hofmann in 1857. He discovered the first aniline dye, 'mauve,' in 1856, and took up the manufacture of dyes at Greenford, retiring from the business in 1873 to devote himself to pure science.

ROYAL COLLEGE OF SCIENCE AND ROYAL SCHOOL OF MINES

The history of the Royal College of Science and Royal School of Mines is somewhat tortuous. The Mining School arose from the Ordnance Geological Survey, instituted by Henry De la Beche in 1832. Three years later authority was given by the Government for a collection of geological specimens, especially substances used for roads or buildings, or from which useful metals are extracted, and this collection became the Museum of Economic Geology, later the Geological Museum in Jermyn

Street, soon to be transferred to a new building at South Kensington. The building in Jermyn Street was finished in 1851 and opened by the Prince Consort, and the Government consented to the resources of the institution being used for public instruction in mining, and in the application of science to the arts. Thus arose the School of Mines and of Science applied to the Arts, opened in November 1851 with a distinguished staff including Ramsay (geology), Warington Smyth (Mining and Mineralogy), Robert Hunt (applied mechanics), Lyon Playfair (practical chemistry), Percy (metallurgy), and Edward Forbes (natural history as applied to geology and the arts), De la Beche being the director of the school. In the first session there were seven matriculated, twenty occasional students, chiefly soldiers, and a few 'ladies and philosophers' granted free admission to the lectures on the nomination of the professors. The first professors were in accord that the school should be the nucleus of the great economical college much talked about at that time—the year (1851) of the great International Exhibition. Lyon Playfair opened the second session with an address on Industrial Instruction on the Continent, pointing out the need for such instruction in this country and commenting on the lack of preliminary training in science shown by the students of the school. The subject of promoting industrial education was much in the air at this time. Queen Victoria, in the speech from the throne at the opening of Parliament in November 1852, said: 'The advancement of the Fine Arts and of practical science will be readily recognised by you as worthy the attention of a great and enlightened nation. I have directed that a comprehensive scheme shall be laid before you, having in view the promotion of these objects towards which I invite your aid and co-operation.' On the transfer of the Royal College of Chemistry in 1853, the school assumed the title, 'Metropolitan School of Science applied to Mining and the Arts.' But Government mills grind slowly, and the public, as Edward Forbes said in his inaugural address of 1853, were apathetic, showing greater interest in the new science of table-turning. The following year (1854) however, was memorable owing to the accession of Huxley to the staff in succession to Edward Forbes, and his beneficial influence continued to the end of his life in 1895. Though retired from his professorship, he died in harness as dean of the Royal College of Science and Royal School of Mines. On the death of De la Beche in 1855, another distinguished geologist, Sir Roderick Murchison, was appointed director of the school. In 1857 the former title, Government School of Mines and of Science applied to the Arts, was restored. The number of students remained small, and in 1862 an inquiry into the school was made by a Government Committee, in consequence of which the title was altered to the Royal School of Mines, and a diploma of associateship was established. A select committee of the House of Commons, presided over by Mr. Samuelson, was appointed in 1868 'to inquire into the provisions for giving instruction in theoretical and applied science to the industrial classes,' and took evidence about the Royal School of Mines. Huxley vigorously defended the school. 'I must take leave to deny,' he said in evidence, 'that the School of Mines has been a failure.' He admitted that the number of students was comparatively small, but even if the school 'had done nothing more than show the value of scientific training the school had been a considerable success.' He commented on the ignorance and apathy of the manufacturing classes and their want of appreciation of scientific training. Conditions improved greatly with the transfer of the science departments to the new building at South Kensington in 1872, followed in 1877 by geology, and in 1880 by mining and metallurgy.

TECHNICAL EDUCATION

London can claim to have taken an active part in the establishment of the national system of technical education. The International Exhibition of 1851, initiated by the Royal Society of Arts and strongly supported by the Prince Consort, drew attention to the importance of scientific education. From its profits the estate was acquired at South Kensington on which sites have been provided for a splendid group of buildings used for the promotion of science and art; in addition a considerable income arising from the estate is used for the promotion of scientific education by the grant of scholarships. At this early stage the stimulus was towards scientific rather than technical education, the urgent need for mining education having already received attention from the Government. The Industrial Exhibition at Paris in 1860 drew attention to our deficiencies on the industrial side, and a strong letter thereon addressed by Lyon Playfair, a member of the original staff of the School of Mines and Science applied to Arts, to the Taunton Commissioners appointed in 1864, started the movement for organised technical education in Great Britain. An appeal was made to the city of London and its Guilds to assist in the promotion of technical education, with which the Guilds as first established were concerned. The City and Guilds of London Institute was founded in 1878 for the purpose of 'all such branches of science and the fine arts as benefit or are of use or may benefit or be of use to productive and technical workers, especially to commerce and industry generally . . . . .' It established two important technical colleges, the Finsbury Technical College (now closed), honourably associated with the name of Silvanus Thompson, and the Central Technical College, now entitled the City and Guilds Engineering College at South Kensington, the most important engineering college in the country. On an adjoining site granted by the Commissioners of the 1851 Exhibition, an extension of the City of Guilds Engineering College was completed in 1914, containing laboratories for hydraulics, structural engineering and railway engineering, the cost of the building being defrayed by the Goldsmiths' Company. Mr. C. T. Millis, the historian of technical education, states that the total grants of the City Companies to the City and Guilds Institute amounted to the end of 1924 to £1,122,994, the Goldsmiths' Company heading the list with £204,523, followed by the Clothworkers, the Fishmongers, and the Mercers Companies.

LONDON POLYTECHNICS

Birkbeck College survived its early difficulties and gradually changed its character. The Birkbeck Institution, the City of London College (founded 1860), and the Northampton Polytechnic were combined under an Order in Council of 1891 to form the City Polytechnic, an abortive scheme which might have served as a warning. The Working Men's College, founded in 1854 by F. D. Maurice, provided, as its title indicates, for the same class but aimed at a wider culture. With the increasing population of London, the older institutions were unable to provide a complete system of technical education for London. The story of the London Polytechnics is told by Mr. Sidney Webb (Lord Passfield) in *London Education* (1904). The word polytechnic, he explains, was not borrowed from France, Germany, or Switzerland, but was due to the local accident that Quintin Hogg, founder of the first polytechnic, acquired the lease of premises in Regent Street known as the Polytechnic and used for popular and semi-scientific entertainment. Quintin Hogg was a philanthropist rather than an educationalist. The London polytechnics have always shown a strong social bias, combining social intercourse, recreation, and instruction. Funds rendered available by the City Parochial Charities Act, 1883, were used to promote the establishment of polytechnics and the City Companies supported the movement. The Drapers' Company took over the People's Palace in East London—a palace which had arisen out of Sir Walter Besant's dream in *All Sorts and Conditions of Men*; it is now in part

East London College; the Goldsmiths' Company established a polytechnic at New Cross (now transferred to the University of London and used as a training college for teachers), and the Clothworkers' Company made a large contribution to the Northern Polytechnic at Holloway. Fifteen institutions and branches at work in 1903-4 had involved a capital outlay of a million sterling, and others have since been established. Many of the polytechnics are provided with well-equipped scientific laboratories and work of a high order is carried on, including courses of post-graduate standard. By a special provision of the statutes the University of London as re-constituted in 1900, was authorised to 'recognise' teachers in institutions of heterogeneous character such as the polytechnics, and matriculated students attending the courses of such teachers are able to qualify for internal degrees of the university. 'London,' says Mr. Webb, 'has not only a decentralised but also an "evening class" university of the most popular kind'—a pure addition to the educational system, not competing with other institutions. In addition to polytechnics of a general character, there are in London a number of monotechnic institutes for special industries such as the leather industry, printing, optics. In 1929 there were in London seventy technical institutions maintained or aided by the London County Council, with an enrolment of 69,804 students.

WOMEN'S EDUCATION

London can also claim to be a pioneer in women's education. Queen's College, the first college for women, founded by F. D. Maurice, was established in Harley Street in 1848 'for general female education and for granting to governesses certificates of qualification.' Instruction was given in lectures by gentlemen connected with King's College and other professors. There were also preparatory classes and evening classes, the latter gratuitous; the whole superintended by ladies as visitors. Queen's College was the nursery of Miss Buss and Miss Beale, who raised the torch of learning at the North London Collegiate School and Cheltenham College. Bedford College soon followed, being founded in 1849 by Mrs. Reid to provide a liberal education for women, such education not to extend beyond secular subjects. Established originally in Bedford Square, it migrated to Baker Street and in 1914 to Regent's Park, where it occupies a site of eight acres of great natural beauty. Bedford College for Women is now the largest college of university standing for women in the country. King's College started classes for women in Kensington in 1877, now represented by the women's department of King's College in the Strand, since 1915 a co-educational college, and by King's College of Household and Social Science at Campden Hill, now an independent institution. Westfield College, Hampstead, was founded in 1882 by Mrs. Dudin Brown for the higher education of women, including instruction in the Christian religion. The London School of Medicine for Women, associated with the Royal Free Hospital, provides medical education for women. Several of the general colleges and two medical schools in London, those connected with University College and King's College Hospitals, are co-educational. London University established a special examination for women in 1868, but ten years later obtained powers to admit women to all examinations. London has been active also in promoting secondary education for girls. In May, 1871, at a meeting at the Royal Society of Arts, Mrs. William Grey (née Shirreff) proposed an 'educational charter for women,' claiming their right to share with men an education 'the best for human beings,' irrespective of sex, and a share for girls of ancient and future educational endowments, and proposing the registration of teachers in order that the schoolmistresses' profession might be as honourable and honoured as the schoolmasters'. Girls, she said, were not educated to be wives, but to get husbands. This meeting led to the foundation in 1872 of the Girls' Public Day School Trust, with its admirable motto, 'Knowledge is now no more a fountain sealed.' The Trust founded thirty-eight schools between 1872 and 1901, and twenty-five were flourishing in 1923 when *The Jubilee Book of the Girls' Public Day School Trust* by Mr. Laurie Magnus was published. The Trust he says, 'sowed Greater London with seats of learning.' At the great service of thanksgiving held in St. Paul's Cathedral to celebrate the jubilee, the bidding prayer remembered with honour and commemorated with joy the labours of Henrietta Maria Stanley of Alderley, Maria Georgina Grey, Emily Shirreff, and Mary Gurney. The Church Schools' Company, founded in 1883, established several secondary schools for girls with a more definite religious basis.

MEDICAL EDUCATION

Medical education in London is mainly carried on in medical schools directly associated with the great hospitals, to which reference is made in the following chapter—St. Bartholomew's, St. Thomas's, Westminster, Guy's, St. George's, London, Middlesex, Charing Cross, King's College Hospital, University College Hospital, St. Mary's, the Royal Free Hospital. Organised medical education is a comparative recent institution. From the viewpoint of placing it on a scientific basis, the establishment of University College and King's College with their departments of anatomy and physiology, was an important development. The Medical Act of 1858 creating the General Medical Council, led to various improvements.

The education of the London medical student to-day is primarily professional, carried on, after completion of the preliminary and intermediate studies, in the wards of the hospitals under clinical professors. There are well-equipped institutes of physiology and of anatomy at University College, and many of the hospitals have research departments for special diseases such as cancer. This system is being supplemented on the scientific, post-graduate, and research sides by new institutions such as the London School of Hygiene and Tropical Medicine, and the proposed post-graduate hospital at Hammersmith. The establishment of the London School of Hygiene and Tropical Medicine in Malet Street, Bloomsbury, was made possible by a munificient donation of £400,000 from the Rockefeller Foundation towards the cost of the building, and by the co-operation of the Ministry of Health. The school has set a new standard in its character and equipment and is a good example of the possibility of concentrating scattered effort in this great city. The school is imperial and international in its scope, a link between the homeland and its overseas possessions, 'a Mecca,' as its first director, Sir Andrew Balfour, has said 'to which the devout scholars of medicine and hygiene might resort, not only with a view to acquire knowledge but to conduct research and to give opportunities of discussing their problems and perplexities.' He made the humiliating reflection that in no single instance has the causative organism of any of the common communicable diseases in this country been discovered by a British worker. If, as a wit suggested, the school helps to make this country 'a fit place for Americans to live in'—he was referring particularly to our methods of handling food—our debt to the Rockefeller Foundation will be repaid.

The Ministry of Health is also taking an active part in establishing the first graduate hospital at Hammersmith, an institution which should remove the reproach under which London has suffered for many years of failing to make full use of its unrivalled clinical resources for teaching and research in medicine. This important scheme is based on the unanimous report of a committee appointed by the Minister of Health in July, 1925: 'More than thirty years ago,' the committee say, 'it became obvious that the provision of facilities for post-graduate study was a pressing problem.' Since then even the wayfaring man realises that the practice of medicine has been revolutionised by such discoveries as radium and new light rays. Another research development announced this year (1931) is the building and endowment of a research farm for the Royal College of Surgeons at Downe, Kent, adjoining Darwin's old home, the benefactor being Mr. George Buckston Browne, F.R.C.S. In his letter to the president of the Royal College of Surgeons, announcing his gift, Mr. Buckston Browne expressed his belief that those who add to the science and practice of surgery are the greatest of all benefactors to the human race and the domesticated animal kingdom.

How many great names in the history and practice of medicine have been associated with the London hospitals, and their medical schools—William Harvey, discoverer of the circulation of the blood, and Abernethy (St. Bartholomew's), Richard Mead and Sir John Simon (St. Thomas's), Richard Bright and Ashley Cooper (Guy's), John Hunter and Edward Jenner (St. George's), Huxley (Charing Cross), Richard Quain and William Jenner (University College), and pre-eminently Lister, a veritable son of London, educated at University College and Hospital, and in the last years of his professional life professor at King's College and Hospital.

A London Charlottenburg

When the University of London was reconstructed in 1900 as a teaching university, the question arose of filling *lacunae* in the higher education of London. Mr. Haldane, who had taken a powerful part in securing the passage of the University of London Act of 1898, under which the university was reconstituted, took up the question of creating a London 'Charlottenburg,'[1] as the apex to its system of technical education. Sir Almeric Fitzroy, Clerk of the Privy Council, recounts in his *Memoirs* that on May 28, 1902, Haldane secured the adhesion of the Duke of Devonshire, then president of the council, for the formation of a great trust for this purpose in connection with the university, for which it was hoped that a capital sum of £600,000 would be immediately forthcoming, £400,000 of which would be used for technical chairs and £200,000 for post-graduate research. 'It is a great scheme,' says Fitzroy, 'and worthy of the fertile and daring brain of its organiser.' Haldane also secured the support of Mr. Sidney Webb and of the Technical Education Board of the London County Council. Fitzroy writes of a further meeting on June 25, 1902, at Lord Rosebery's house, attended by Sir Julius Wernher (whose firm, Messrs. Wernher & Beit, had contributed generously to the scheme), Sir Arthur Rücker, principal of the university, and Mr. Sidney Webb. 'Enough was said and hinted at to ensure the accomplishment of the general design.' A further entry in the *Memoirs* under date October, 27, 1902, records the strong approval of King Edward VII of the London 'Charlottenburg' scheme, 'which his father would have created but for his premature death.' The proposal was publicly announced in the letter dated June 27, 1903, which Lord Rosebery as chancellor of the university addressed to Lord Monkswell as chairman of the London County Council. Haldane in his *Autobiography* (1929) states that the separation of technical and university education in Germany had made an unfavourable impression on him and he decided to work in London on a different principle. But the relation of the new constitution to the university became a subject of controversy. After much discussion a Royal Charter was issued in July, 1907, to the Imperial College of Science and Technology at South Kensington, to include as integral parts the Royal College of Science, the Royal School of Mines, and the City and Guilds Engineering College, the question of the incorporation of the college in the university being left open. The purposes of the college as defined in the charter are 'to give the highest specialised instruction and to provide the fullest equipment for the most advanced training and research in various branches of science, especially in its application to industry and to do all or any of such other things as the Governing Body hereinafter instituted consider conducive or incidental thereto having regard to the provision for those purposes which already exist elsewhere.' The question of the relation of the college to the university was referred to the Royal Commission, presided over by Haldane, appointed in 1910 with wide terms of reference in relation to university education in London. This Commission recommended in 1913 a reconstitution of the university, but the Great War intervened and the matter went into abeyance. In 1926 an Act was passed for the reconstitution of the university and the statutes made thereunder were sealed on July 23, 1928. Under these statutes the university is at present governed.

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[1] Cf. Chap. V, p. 195.

THE NEW UNIVERSITY OF LONDON

Statutes do not make a university, but the University of London Act of 1926 on which the new statutes were based was public recognition that the controversies of the period from 1900 to 1913 were leading nowhere. It is not easy to diagnose whether a university has acquired a new heart—different physicians would apply the stethoscope in different places—but at any rate the University of London is soon to acquire a new body, a new headquarters on an island site of ten acres behind the British Museum, purchased in 1927 with the help of a grant of £400,000 from the Rockefeller Foundation. Two years were spent, and well spent, in securing Parliamentary powers to close the roads intersecting the site, and in the present year (1931) the appointment of Mr. C. Holden as architect has been announced.

The vineyard of science is large, but happily the labourers are many. In his report for 1930-31, the principal of the university recounts statistics reminding of astronomy, the first science 'professed' in London—10,531 admissions by all channels during 1930-31, compared with 3,852 in the last year before the War, 39,323 candidates for examinations, and 3,381 degrees and diplomas granted in 1930, and a roll of 10,281 internal students. A substantial proportion of these students are eager to

> 'Probe nature's secrets, wrest them to our need,
> Live glorious years in one heroic day.'

May Francis Bacon's Solomon's House be seen rising in the heart of London! Will not London become the Scene of Science?

CHAPTER V

GOVERNMENT AND SCIENTIFIC RESEARCH

By SIR FRANK HEATH, G.B.E., K.C.B.[1]

THE history of the interest shown by Government in scientific research is longer than is generally thought. It is true that the whole range of natural science was not brought within its influence until the present century. It is equally true that until this last decennium there was no realisation by the State of the essential unity of modern science, and consequently no attempt to consider its relations and importance to the community as a single and co-ordinated if complex problem. It is also true that the attitude of Government to science and to the higher teaching on which its progress so largely depends, has been tentative and of slow development. Practical needs have throughout been the principal, though not the only stimulus to action. But the goad was felt as early as the fourteenth century, and as the functions of Government have widened, especially in modern times, its prick has come to be felt in every part of the body corporate. It is not surprising, therefore, that we find the State in the main concerned with utilitarian purposes rather than the advance of knowledge for its own sake, though the colour of intellectual thought in the seventeenth century, and the realisation in our day of the dependence of health, agriculture, and industry on the progress of disinterested science have, as we shall see, widened the outlook of the national policy and led it to have regard to more than mere material ends.

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[1] Excepting certain paragraphs of which separate acknowledgment is made.

The needs of national defence have, from the beginning, been of primary influence on the attitude of the State to science. Gunpowder was manufactured in England in 1344, and Edward III controlled the supplies of sulphur and saltpetre in 1346. Its manufacture was a crown monopoly in Elizabeth's time, and powder mills probably existed at Waltham Abbey in her days. In the eighteen-twenties a chemist was on the staff of Woolwich Arsenal, and Faraday, who had become director of the Royal Institution laboratory in 1825, was appointed to lecture at the Royal Military Academy (1829-53).

The Government's interest in gunpowder was the accidental means of helping it to meet another practical need. The sale of spoilt powder in 1675 provided Charles II with the means of building an observatory in Greenwich Park for John Flamsteed, the astronomer, whom he had appointed 'astronomical observator' at a salary of £100 a year to correct the tables of the heavenly bodies and to rectify the places of the fixed stars 'for the use of his seamen.' Flamsteed had also to provide his own instruments and to teach two boys from Christ's Hospital. But Charles did not escape the influence of the scientific thought of his time. Men of science working in diverse fields and different lands were beginning to fertilise each other's ideas. Galileo used the telescope for astronomy; Pascal used the Torricellian tube to test the weight of the atmosphere. Leibnitz' work on the calculus, Huygens' wave theory of light, Halley's prophecy of his comet's return, all influenced Newton, and Newton was calling for Flamsteed's corrections to enable him to perfect his own lunar theory. When Charles granted his charter to the Royal Society in 1660 he was acting under a general impulse that led to the foundation of all the great European academies of science in that century. Yet his interest in the disinterested advance of knowledge remained purely intellectual, unless indeed one may see in Newton's appointment as Warden of the Mint an attempt at some indirect support. Parliament, however, remained severely practical, and at the instance of a number of naval captains and merchants enacted the recommendation of its committee that 'a reward be settled by parliament upon such person or persons as shall discover a more certain and practicable method of ascertaining the longitude than any yet in practice.'[1] The next step in this direction, equally utilitarian in object, was the establishment by the Board of Trade in 1854 of a Meteorological Office in the interests of the merchant navy (see p. 228).

The maintenance of a standard currency became another necessity as the trade of the country grew, and this led to the experimental work of Hewson in the early eighteenth century, and to the researches of Alchorne, August von Hofmann, Thomas Graham, William Allen Miller, and John Stenhouse, followed by the notable advances in metallurgy made by Sir William Roberts-Austen, in the nineteenth century. But metallurgy was no less important for war material, and it was Dr. Percy at the Ordnance College and the Royal School of Mines, both Government institutions, who first placed that science on a firm basis. His work was developed and extended by Sir Frederick Abel, who became War Department Chemist in 1856, and when the Research Department, Woolwich, was established jointly by the Admiralty and War Office in 1904, one of its divisions was devoted to metallurgy.

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[1] See, further, Chap. V, for the resulting invention of John Harrison.

Next to the currency came the need to safeguard the State's interests in mining royalties. That interest was aroused by Henry Thomas de la Beche, who became the first director of the Geological Survey of Great Britain in 1835. But revenue came not only from royalties. Of equal or greater importance was that from the customs. To defend that source the Inland Revenue Laboratory was established in 1843, the first duty of which was to detect adulteration in dutiable articles, and particularly tobacco. It was, however, soon to be used in support of the long series of Food and Drug Acts which were passed as the expression of the awakening interest of the public in questions of health. Thus in the main the story of this laboratory and of the activities of the Government Chemist at its head, belongs to public health and medicine, which are dealt with elsewhere (Chap. VIII). Its range, however, is wide, and it may be conveniently considered here.

GOVERNMENT LABORATORY[1]

The Government Laboratory is a department of the Treasury with a separate vote under the designation of the Department of the Government Chemist. It has been a separate department since 1911 for the purpose of centralising, as far as is practicable, Government chemical work. It thus performs services in connection with chemistry for a great variety of departments of State, and, under certain conditions, for other departments not maintained by United Kingdom funds. Its headquarters is at Clement's Inn Passage, Strand, W.C.2, but in addition there are laboratories at the Custom House, London, Liverpool, and several other ports; in addition it maintains laboratories for the Geological Survey and at Deptford for inspection of War Office foodstuffs.

The principal activities of the Government Laboratory are in connection with agricultural products, fertilisers, and feeding stuffs, work in connection with Crown contracts for chemical stores for various departments, and work for the Department of Customs and Excise, on which depend ultimately charges for both duty and drawback.

The Government Chemist, as indicated above, is the official referee under the Sale of Food and Drug Acts and under the Fertilisers and Feeding Stuffs Act.

The work of the department covers a very wide range, as is indicated above. It is concerned with the purity of air, the potability of waters, the pollution of rivers, and the salinity of sea water; the quality of many imported foodstuffs and their marking under various acts, including the new National Mark scheme; with examinations and advice for the Department of Customs and Excise as to dutiable liquors, sugar, chocolate, tobacco, tea, hydrocarbon oils, silks, and substances liable to Key Industry Duty; with dangerous drugs and advice to the Post Office and Record Office on documents and stamps. In addition, it carries out investigations for various departments and committees on various subjects, of which recent examples are those on Ethyl petrol, sulphur in flue gases, pollution of rivers, and determination of substances in minute quantities. For such researches trained chemists are sometimes seconded to other bodies. The work is carried on by the Government Chemist and his deputy, together with an established staff of fifty-six chemists, assisted by a large auxiliary staff.

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[1] This section has been kindly supplied by Sir Robert Robertson, K.B.E., F.R.S., Government Chemist.

THE SCIENTIFIC ADVANCEMENT OF INDUSTRY

It was not till the middle of the last century that the State became concerned with the progress of industry as such. Its first overt act was the Great International Exhibition of 1851, the direct result of the Prince Consort's interest in the application of art and science to manufacture. That exhibition, and still more the exhibition of 1862, revealed to the British producer who, from the time that steam had become an effective source of power, had been practically the universal provider of manufactured goods, the rapid strides being made by other countries along the same road to prosperity. The Prince foresaw the coming power of chemistry, and through his influence the great German chemist, Hofmann, came over here to teach in the Royal College of Chemistry (1845) and subsequently in the Government School of Mines and Science applied to the Arts[1] which was established in 1851 in the basements of the Museum of Practical Geology in Jermyn Street. The profits from the Great Exhibition were vested in a Royal Commission which has developed South Kensington as a great centre of the applied arts and of scientific and technical education of the highest grade, while in 1853 the Department of Science and Art was founded to spread scientific and artistic education throughout the country. 'South Kensington' soon became its soubriquet. The Royal Commission, moreover, by its advanced scholarships has picked out many a distinguished leader of science from this country and from the Empire overseas, who without its timely help might never have had a chance of showing their capacity. But all this, it will be noted, had regard to the interests of industry as a whole; scholarships to provide well-trained men; exhibitions and museums to show the best that had been produced here or elsewhere; colleges and schools where those who would might learn, and if capable enough, do original work. Industry was expected to do the rest.

Then came the first appreciation of the importance of inter-imperial trade and with it the foundation, again at South Kensington, of the Imperial Institute, as a memorial of Queen Victoria's Jubilee, in 1888. The whole empire shared in this foundation, and although, for reasons too complicated to explain here, it failed to realise all the hopes of its founders, it is specially interesting in the history of the State's relation to scientific research for industrial ends, because its charter expressly included research into the uses of raw products from overseas (see further, Chap. IX).

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[1] See further, Chap. IV, p. 173.

Meantime, the new German Empire had begun in a characteristically thorough way to promote the prosperity of its relatively young industries by a comprehensive policy of encouragement which included tariffs, preferential railway rates, the foundation of a Physikalisch-technische Reichsanstalt at Charlottenburg in 1887, and later the establishment of a series of technical high schools which in time achieved the full status of universities. The influence of this movement upon education in London falls for consideration in Chap. VII. The late Lord Rayleigh, among others, was quick to appreciate the importance of the Charlottenburg Institute. He realised that the progress of modern industry depends on an ever increasing accuracy of measurement, and that no single industry, far less any single firm, however large, could undertake the determination of the numberless standards and constants, the accuracy of which limits their performance. This is a form of research which can only be undertaken by some national organ. He was fortunate in finding a sympathetic sponsor in a member of the Government, his brother-in-law, Arthur James Balfour, who later in life, as Lord President of the Council, became the first active Minister of Research in this country. In 1902 the National Physical Laboratory was opened by the Prince of Wales, the Government having provided the Royal Society with Bushy House—a royal residence—a capital grant of £19,000 for alterations and equipment and an annual grant of £4,000 for five years.[1] The Prince in his speech at the opening, pointed out the significance of the new foundation. 'I believe,' he said, 'that in the National Physical Laboratory we have almost the first instance of the State taking part in scientific research. The object of the scheme is, I understand, to bring scientific knowledge to bear practically upon our everyday industrial and commercial life, to break down the barrier between theory and practice, to effect a union between science and commerce .... Does it not show that the nation is beginning to recognise that if her commercial supremacy is to be maintained, facilities must be given for furthering the application of science to commerce and manufacture?' That sentence is the keynote of all further development in State action within this field from then to the present day.

Side by side with this wakening recognition of the national concern in utilitarian research came a growing realisation of the importance of disinterested investigation, of the pursuit of knowledge for its own sake, as the necessary source from which useful applications to the manifold needs of man, can, for the most part, be derived. The pressure of population and of trade competition, the responsibilities of Government towards backward races, the needs of defence, have all helped to emphasise the value of knowledge as the guide to administration and policy. So we find Government in this century making larger and larger grants to the universities, including since 1922 Oxford and Cambridge, and gradually increasing its grant to the Royal Society for research work from £1,000 a year in 1850 to £6,000 at the present time.

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[1] With reference to events leading up to this foundation, and especially the part played earlier by Kew Observatory, see further *The British Association, A Retrospect*, Chap. V, p. 168; also Chap. X, p. 304, of this volume.

AGRICULTURE, MEDICINE, AND INDUSTRY

Thus far, however, the outlook is still general rather than specific and particular. But just as in the earliest stages, as we have seen, the impetus was towards the solution of special problems or groups of problems, so in the present century also the State has been forced to devise special machinery for encouraging research in the three main fields of agriculture, medicine, and industry, not as the result of any considered or correlated plan, but under the pressure of practical needs. The Development Commission (1909), now largely replaced as regards research by the Agricultural Research Council (1931), the Medical Research Committee (1913), since incorporated as the Medical Research Council, and the Committee of Council for Scientific and Industrial Research (1915), were all due to the recognition of the necessity for some measure of intervention. Each has revealed in its working the unsuspected range alike of its investigations and of its possibilities. Each realises that it is fundamentally part of a single whole which can only function with full effect in close co-operation, not only with the others but with the universities and with every organisation concerned in research that falls within their respective fields of action. It is fortunate, in the writer's opinion, that the almost absent-minded approach of Government to the complex service of scientific research for the modern purposes of a very ancient and highly differentiated community should have led to this tripartite though correlated organisation. The recent appointment of a Committee of Council for Agricultural Research brings all three organs under the Lord President of the Council, though in detailed arrangement and in their relations with other departments of State they differ from each other, as indeed the differences in their history and in their respective activities naturally imply.

RESEARCH FOR AGRICULTURE[1]

The Development and Road Improvement Funds Acts, 1909 and 1910, above referred to, provided a sum of £2,900,000 (subsequently increased) to be used in developing agriculture, rural industries, and fisheries. Grants and loans from this fund may be made by the Treasury if expenditure is recommended by the Development Commissioners, a body consisting of eight members appointed by Royal Warrant. With the approval of the Treasury, and after consultation with the Ministry of Agriculture and Fisheries and the Department of Agriculture for Scotland, the Commissioners have allocated the greater part of the Development Fund to financing schemes for the promotion of agricultural research.

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[1] These sections have been kindly supplied by Sir Thomas Middleton, K.C.I.E., K.B.E., Development Commission.

After a survey of the position of agricultural education and research in the United Kingdom, a policy was adopted in 1911 which has since been closely followed. The fact that a fund was available enabled the Commissioners to plan ahead, and although the nature of the investigators' task prevents the statement that the programme originally mapped out has been completed, it may be claimed that, as a result of the Act of 1909, the main framework of an organisation for prosecuting agricultural research in Great Britain has now been provided.

The policy adopted had in view three main objects. The first of these was the creation of well-equipped and suitably staffed institutions for prosecuting research in certain subjects, such as plant breeding (Cambridge), plant nutrition (Rothamsted), animal breeding (Edinburgh), animal nutrition (Cambridge and Aberdeen), and economics (Oxford). There are now twenty-five of these research institutes in Great Britain; for the most part they are connected with universities, and all of them, except the laboratories of the Ministry of Agriculture and Fisheries for animal pathology at Weybridge and plant pathology at Harpenden, are under the management of independent governing bodies. They are closely associated, however, with the Departments of Agriculture, and mainly dependent for support on State grants. These grants, which in the aggregate now amount to about £185,000 annually, come (except in the case of the two official laboratories) from the Development Fund, and are administered in England and Wales by the Ministry of Agriculture and Fisheries, and in Scotland by the Department of Agriculture.

A second object of the Commissioners' policy was to link up research institutes with institutions providing agricultural education on one hand, and on the other with farmers in the areas served by agricultural colleges. For this purpose arrangements were made to strengthen the staffs of certain teaching institutions by adding specialists in particular subjects. The country was divided into seventeen 'provinces,' and in each a group of specialists (known as advisory officers) is now at work. At first the chief demand was for chemists, mycologists, and entomologists, and when the demand was supplied, economists and veterinary surgeons were added to the staffs of advisory centres. While, as the name adopted shows, the immediate purpose of these specialists is to convey technical advice to agriculturists, it was always intended that much of their time should be spent in investigation; in fact the volume of the original work in which they are engaged is now considerable. The expenditure on this advisory service is now about £85,000 annually. It comes almost wholly from the Development Fund; and payment is made to the advisory centres by the agricultural departments. Close touch is maintained between the agricultural departments and the advisory centres, and departmental officers frequently carry on local investigations in association with the advisers.

It was obvious to those planning the above developments that it would be impossible to give immediate effect to the policy decided upon, as trained workers were not then available. The third of the development schemes adopted in 1911 was, therefore, a project for training. It was, indeed, third only in the demand made for expenditure; in urgency it came first, and a post-graduate scholarship scheme was instituted at once. In each of the three years before the Great War twelve scholars were selected by panels of referees, and were sent for training to institutions in this country or abroad. Two were members of the veterinary profession, the others were honours graduates of British universities. After the war the selection of scholars was resumed, and under this scheme well over one hundred specialists have now been trained, the majority of them being employed in one or other of the above services; some 25 per cent of the number, however, are now at work in the agricultural department of the overseas Empire.

The policy adopted twenty years ago having now resulted in a large organisation for the scientific study of agriculture, it has recently been decided that the time has come when agricultural research should be more closely linked to the other scientific subjects which the State is endeavouring to foster. An Agricultural Research Council has, therefore, been created by the Government under Royal Charter; like the Department of Scientific and Industrial Research and the Medical Research Council, it has been placed under a Privy Council Committee, and officially it is responsible to the Lord President of the Council. Arrangements have been made by the Lord President which will result in close co-operation being maintained between the new Council, the Commissioners, and the

Agricultural Departments. The first meeting was held only on 9 July, 1931, so that the share of this Council's activities in the work described above is still in the future.

RESEARCH FOR FISHERIES

Of the measures taken by the Commissioners to develop fisheries, one only, the encouragement of research, can be referred to.

A survey of the position in the years 1911-13 showed that the provision then made by the State for aiding research was meagre, and also that the problem differed in some essential particulars from that presented by the sister industry, agriculture. At that time the agricultural investigator was working on a subject which had not only received considerable attention from scientific men in many countries, but on which countless observations had been recorded by intelligent agriculturists for three centuries.

The observations and records furnished by the soil had relatively few parallels in the case of the sea; such definite observations as had been taken on the latter had related primarily to navigation. While the *Beagle* had indicated the biologist's opportunities, and the *Challenger* had brought home a store of material, these well-named ships had done little more than track the biologist's 'quarry' and challenge his attention and his endeavours. It was apparent to the scientific committee which, on behalf of the Commission, examined the problem, that most of the funds which could be provided for investigation should be devoted to encouraging 'free' research in the many problems of marine biology that had begun to attract scientific study in the preceding twenty-five years. The Commissioners adopted this view, and while a relatively small sum has been expended in what their committee termed 'directed' researches, *i.e.*, investigations specifically directed to answering certain questions important from an administrative and industrial point of view, the greater part of the expenditure from the Development Fund on fisheries research, which now amounts to about £35,000 annually, is incurred in respect of research which aims, in the words of the committee, at 'a complete knowledge of the sea and the life in it.' While the sea for obvious reasons must claim much the greater share of the funds and scientific energy available for fisheries research, it has also been possible to give some encouragement to the study of freshwater biology.

The chief centres of fishery research are the Plymouth Laboratory of the Marine Biological Association, the Lowestoft Laboratory of the Ministry of Agriculture and Fisheries, the Millport Laboratory of the Scottish Marine Biological Association and the Aberdeen Laboratory of the Scottish Fishery Board. All have other sources of income but except in the last case the main support comes from the Development Fund. Smaller laboratories are aided at Port Erin (Liverpool University), Cullercoats (Armstrong College, Newcastle-upon-Tyne) and Hull (Hull University).

While it is in this ring of laboratories round the British coast that active fishery research is in progress, the claim of fisheries research to a place in this London handbook is not less than in the case of the other subjects here dealt with, for it is largely through the action of the Commissioners' Advisory Committee on Fishery Research that the limited amount of scientific work on marine biology formerly in progress has been developed to its present scale in the past ten years. This committee, which works in close association with the administrative departments and contains representatives of the industry, advises on the grants required by institutions, inspects their laboratories, examines their research programmes, and confers with them on the results being obtained.

RESEARCH FOR MEDICINE

The Prince of Wales, in his presidential address to the British Association in 1926, said: 'It is appropriate to recall, with gratitude for its labours, the constitution of the Medical Research Committee in 1913, under the Insurance Act of 1911; this has since (in 1919) been transferred to a Committee of the Privy Council under the name of the Medical Research Council, and its funds are directly voted by parliament instead of being drawn from the contributions made by or on behalf of insured persons. Research alone could provide the knowledge on which must be based all wise and effective legislation or administrative action in the interests of the nation's health. Yet until 1913 the State had played at best a subsidiary part in the organisation of such research and the provision of its material support. . . . There can surely be no plainer duty, for a State charged with the health of an industrial civilisation, than to promote with all its resources the search for such knowledge as this, as well as to provide for its application when obtained.' The activities of the Medical Research Council to this end fall for consideration at the close of Chapter VIII.

RESEARCH FOR INDUSTRY: THE DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

The Department of Scientific and Industrial Research had its origin in a scheme presented to the Cabinet in 1915, which was the outcome of a widely felt need for action to remove the defects in our industrial organisation revealed at the outbreak of the Great War. The Board of Trade had appointed a committee with the late Lord Haldane as chairman, 'to consider and advise as to the best means of obtaining for the use of British industries sufficient supplies of chemical products, colours, and dyestuffs of kinds hitherto largely imported from countries with which we are at present at war.' The Royal Society and other learned societies interested in chemical research were received in deputation by the Presidents of the Boards of Trade and of Education in May 1915. They pressed for 'Government assistance for scientific research for industrial purposes, the establishment of closer relations between the manufacturers and scientific workers and teachers, and the establishment of a National Chemical Advisory Committee for these purposes.' They were assured 'that the Government had decided to establish machinery with wider powers than had been suggested, so as to make it possible to encourage research, not only in chemical but in all other sciences affecting industry.'[1] In July a White Paper (Cd.8005) was issued describing the scheme, and the Advisory Council, which was the most significant feature of the new organisation, met for the first time on August 17. The object of the Government was stated to be 'to establish a permanent organisation for the promotion of scientific and industrial research' throughout the United Kingdom. And the new plan was intended to serve the interests of the country in peace, even more than in war—though for the time being the claims of defence were paramount. 'We cannot hope,' said Mr. Henderson, the President of the Board of Education, 'to improvise an effective system at the moment when hostilities cease, and unless during the present period we are able to make a substantial advance we shall certainly be unable to do what is necessary in the equally difficult period of reconstruction which will follow the war.'

The Committee of Council, presided over by the Lord President, was appointed by Order in Council 'to direct (subject to such conditions as the Treasury may from time to time prescribe) the application of any sums of money provided by Parliament for the organisation and development of scientific and industrial research.' The Advisory Council, composed mainly of eminent scientific men, some of whom were actually engaged in industry—there were eight members in the first instance—were required to report and make recommendations on all proposals (*i*) for instituting specific researches; (*ii*) for establishing or developing special institutions or departments of existing institutions for the scientific study of problems affecting particular industries and trades, and (*iii*) for the establishment and award of research studentships and fellowships. It is noticeable that though the Council is called advisory it is, in fact, responsible for framing the scientific policy of the department. Every proposal for research, from whatever source it comes, 'stands referred' to the Council for their consideration and report, and the yearly estimates must be approved by them before submission to the Minister and the Treasury. It is also significant that the first chairman of the Council, the late Sir William McCormick, was also chairman of the University Grants Committee, the body responsible for advising the Treasury as to the grants made quinquennially by Parliament to the universities and the three university colleges at Southampton, Nottingham, and Exeter. Thirdly, the seven other members of the Council were all Fellows of the Royal Society, and though the Council was later enlarged to include certain leading industrialists who were not Fellows, an amending Order in Council was passed in 1928 providing that all future appointments should be made after consultation with the Royal Society. The present chairman of the Council, Lord Rutherford, was president of that society for the five years previous to his appointment. Thus the constitution of the Advisory Council linked it very closely with the premier scientific organ and with the centre of the national policy for university education.

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[1] Report of the Committee of the Privy Council for Scientific and Industrial Research, 1915-16, Cd.8336. p. 8.

In 1916 the Committee of the Privy Council was established as a separate Department of State with its own vote in Parliament and its own administrative staff. The dual relation of the new organisation to education and industry had been recognised from the beginning by the inclusion of the President of the Board of Education and the President of the Board of Trade on the Committee of Council, but it soon became evident that the work to be undertaken must have intimate reactions on the responsibilities of many other Government offices, and in consequence all interested departments were invited to appoint assessors to the Advisory Council with power to attend its meetings and take part in its discussions, but not to vote. In the year 1916-17 there were twenty-one such assessors representing fifteen different departments. At present there are twenty-two assessors from twenty departments. In practice, however, an assessor only attends the Council when business arises in which his own department is interested.

RESEARCH ASSOCIATIONS

In spite of the growing difficulties which the war placed in its way, difficulties which were changed in character though scarcely in number on the coming of peace, the new organisation grew rapidly. After a first year devoted mainly to study of the situation and to formulating plans for the future, eleven special research and enquiry committees were set up and the Advisory Council had worked out a scheme for co-operative research associations to be established by the industries of the country with the assistance of grants from the department. The Council further initiated the policy of making grants to young graduates who had shown promise of capacity for original work to enable them to undertake research under the guidance of the professors who nominated them. In this way it was hoped to assist the creation of schools of scientific thought at the universities and to increase the number of men and women capable of doing the scientific work which it was expected the industries would undertake through their research associations and in the laboratories attached to particular firms. During the academic year 1916-17 rather over £3,500 was spent in this way; in the next year £7,500, and in 1929-30 nearly £29,500. To enable the department to make agreements with industries for the necessary support of the proposed research associations over a period of at least five years, the Government placed a fund of a million sterling at its disposal from which grants could be made, usually on a pound for pound basis. The fund was vested in the official members of the Committee of Council who were incorporated by Royal Charter as the Imperial Trust for Scientific and Industrial Research. The interest on the capital sum has been used to assist schemes for co-operative research in industry, which, for one reason or another, could not be brought within the scheme for Industrial Research Associations, while the capital itself has been devoted to the original plan. Eighteen industries had formed associations by July 1920, and twenty-four were in existence by the middle of 1921. At present nineteen are in receipt of grant while of the remainder three have ceased to exist though the research work they initiated is being continued by the industries concerned. Up to March 31, 1930, £781,000 of the original fund had been spent, and the associations had received subscriptions from their constituent firms—over 4,000 in number—amounting to some £1,250,000. The direct, and even more the indirect results of this movement have been highly encouraging and far-reaching. The attitude of many industries, and more particularly of the more progressive firms, to science and to scientific methods has profoundly changed in the last fifteen years and is by no means confined to those which have come within the ambit of the Research Association scheme. The department has influenced and assisted many other industries and individual firms through other sides of its organisation in constantly growing measure, and has increasingly won their confidence and co-operation.

In the London area the following research associations have established laboratories of their own or are using research laboratories in that area. The first research association founded in London and still in active being is the British Scientific Instrument Research Association, with its laboratories in Russell Square, where the needs of British scientific instruments makers are catered for. This association started work in the year 1918. In 1919 the British Boot, Shoe, and Allied Trades Research Association was formed, but it was not till several years later that the present laboratories in Tavistock

Square were equipped for the purposes of the boot and shoe industry. In the same year the British Association of Research for the Cocoa, Chocolate, Sugar Confectionery, and Jam Trades was founded, with its laboratories in Dalmeny Avenue in Holloway. In 1920 several research associations with laboratories now in the London area were formed. These are the Research Association of British Motor and Allied Manufacturers at Chiswick; the Research Association of British Rubber Manufacturers at Croydon; the British Non-Ferrous Metals Research Association at Euston (though previously their headquarters were at Birmingham); the British Launderers' Research Association, with their laboratories at Hendon; the British Leather Manufacturers' Research Association, with laboratory accommodation provided both at the Lister Institute and the Battersea Polytechnic; and the British Electrical and Allied Industries Research Association, a large portion of whose experimental work is conducted through the agency of the National Physical Laboratory.

In 1923 the Research Association of British Flour Millers, with laboratory accommodation at St. Albans, on the outskirts of London, was formed, and in 1925 the British Food Manufacturers' Research Association was instituted in close collaboration and in connection with the association previously referred to for the cocoa, chocolate, and jam trades, with laboratory accommodation in the same building and under the same director. The most recent association to be formed in the London area is the Research Association of British Paint, Colour, and

Varnish Manufacturers, with laboratories at Teddington.[1]

The other activities of the Department can be only briefly summarised. In 1918 a full-scale Fuel Research Station was erected at East Greenwich at an initial cost of about £120,000 for buildings and equipment, to enable a systematic study to be made of all fuel problems and especially, in the first instance, the low-temperature carbonisation of coal. Simultaneously, plans were laid for a complete chemical and physical survey of the coal resources of the country. The annual expenditure on fuel research is now about £95,000 a year. Local committees have been established for the survey with provision for local investigations throughout the country.

THE NATIONAL PHYSICAL LABORATORY

In the same year (1918) the Royal Society transferred to the department the responsibility for the maintenance and development of the National Physical Laboratory. The great extensions in the laboratory and its work caused by the war, had thrown administrative and financial responsibilities upon the society greater than it could undertake consistently with its primary functions. Already before the war the laboratory had begun investigations into aero-dynamics at the instance of the Government, which was laying the foundations of an air-force, and the special grant for these researches amounted in 1916-17 to £10,400. The total net cost to Government of the maintenance of the laboratory services in the year it was taken over had grown from the initial grant of £7,000 a year to nearly £90,000, excluding the capital cost of buildings and their maintenance. By 1920-21 the maintenance of the scientific work had risen to £148,000 exclusive of fees (£55,000), but in 1929-30 it had fallen to £100,000, while receipts from fees had risen to £104,000. Thus, though the total expenditure on scientific work in this great institution has more than doubled since it was taken over by Government, the receipts from research done for other Government departments, outside bodies and firms exceed those from the department itself, and are nearly twice the amount received from these sources ten years ago. The laboratory is divided into seven distinct departments dealing with physics, electricity, metrology, engineering, metallurgy, aerodynamics, and the William Froude National Tank for the study of the performance of every kind of ship, including flying-boats. The laboratory holds and maintains the standards of electrical resistance, current, and pressure, and issues the necessary certificates in connection therewith on behalf of the Minister of Transport. It also has the custody and the duty of re-verifying the primary national standards of the imperial metric systems of weights and measures, and the construction, maintenance, custody, and periodical re-verification of derived Board of Trade standards of weights and measures, acting in these matters as agents of the Board. The Superintendent of the Metrology Department at the laboratory is also

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[1] The editor gratefully acknowledges the co-operation of Messrs. Ll. S. Lloyd and A. L. Hetherington, Department of Scientific and Industrial Research, in compiling the foregoing paragraphs on research associations in London.

Deputy Warden of the Standards under the Board of Trade. In a word it may be said that the development of the National Physical Laboratory is a record of the growing co-ordination in the scientific work of Government departments and of the co-operation with industry that the existence of the Department of Scientific and Industrial Research has made possible.

GEOLOGICAL SURVEY

In 1919 the Geological Survey of Great Britain and the Museum of Practical Geology in Jermyn Street were transferred from the Board of Education to the department. In that financial year the cost of this service was slightly over £40,000. In 1929-30 the development of its work had led to an increased net expenditure of £68,000.

FOOD INVESTIGATION

In 1918-19 a Food Investigation Board was established by the department to study the storage and transport of food-stuffs. This Board works in close co-operation with the Medical Research Council, whose secretary is a member, with the Ministries of Health and Agriculture and Fisheries, and with the corresponding department in Scotland, all of which appoint assessors to the Board. A Low Temperature Research Station for bio-chemical and bio-physical research was opened at Cambridge in 1921 on a site provided by the university and governed by a delegacy appointed in agreement with the department. The station, with its equipment which cost nearly £34,000, has recently been nearly doubled in size with the aid of a grant of nearly £38,000 from the Empire Marketing Board. This Board also provided funds in 1928 for the erection of an experimental station at East Malling, Kent, for the study of fruit-storage on a semi-commercial scale, and the adaptation of buildings at Aberdeen for a fish research laboratory. The Food Investigation Board is working in collaboration with the overseas authorities of Australia, New Zealand, South Africa, and Canada, in the transport of food-stuffs and particularly fruit, as well as with the shipping and railway undertakings with results of value to producer and consumer alike. In 1919-20 the expenditure of the Board was rather over £18,500. In 1929-30 the net cost to the department was only £16,421, but since its receipts from outside totalled over £24,000, its total budget was over £38,500, another evidence of successful work, and especially of the value put on it by the Empire Marketing Board, the principal contributor.

BUILDING RESEARCH

In the autumn of 1920 the department moved into a new field it had been studying for some time, by establishing a Building Materials and Construction Research Board. Temporary laboratories were first erected at Acton, and the expenditure for research amounted to nearly £6,000. In 1925, however, a permanent Building Research Station was provided at Garston, near Watford, by adapting a spacious house in large grounds which enabled additional buildings to be erected. The national housing policy had revealed the need for a scientific approach to one of the oldest and certainly most conservative of all industries, while the wide-spread responsibilities of Government itself through its Office of Works, called in almost equal degree for the help of research. In 1930-31 the total expenditure of this Board was nearly £37,000, of which nearly £4,500 represented external receipts. The slow growth of the receipts is a measure of the loose organisation of this great industry.

FOREST PRODUCTS RESEARCH

In 1921 as the result of the British Empire Forestry Conference of 1920 it was decided to establish a Forest Products Research Board under the department to work in collaboration with the Forestry Commission, which was responsible for research in silviculture, and to study the characteristics and preservation of home-grown and imported timbers. The expenditure during 1922-23 was under £3,000, for time was needed to survey its wide field of work and outline its plan of campaign. A small seasoning plant and a testing laboratory were opened at the Royal Aircraft Establishment, Farnborough, with the goodwill of the Air Ministry, which was interested in the problems, but this was recognised as a temporary arrangement. By 1926 the plans of the Board were far enough advanced to justify the provision of a permanent Forest Products Research Laboratory at Princes Risborough, a place carefully selected as near a principal centre of the wood-using industry and within equally easy reach of the new Forestry Institute at Oxford, the Building Research Station at Watford, and headquarters in London. The new buildings were far enough advanced in the summer of 1927 to permit all the work to be transferred thither. Since then progress has been rapid. The expenditure on research during 1929-30 was nearly £37,600. Quite recently a special organisation has been created at the station for the investigation and testing of Empire timbers on behalf of the Empire Marketing Board, with a view to developing the timber resources of the Empire.

The activities of the department so far described have all been primarily industrial in outlook. Even the grants made to post-graduate students for research at the universities were made in the first instance in order to stimulate the supply of well-trained workers available for employment in industrial laboratories, but they were also intended to help in building up schools of research under professors of original mind, from which a constant stream of young research workers might be looked for in future. The subjects for investigation are chosen by the nominating professors and expressly not expected to be industrial in purpose. To further this fundamental object of creating schools of research the department also began early in its history to make grants to carefully chosen university teachers to enable them to retain qualified research assistants for their laboratories, and so to increase their own productivity in fields of work they themselves had selected. The Advisory Council recognised from the first that disinterested research is the source of many of the most striking advances in the application of science to manufacture, but that though it may be assisted and encouraged it cannot be organised. As part of this policy the department on their advice has, from time to time, met the cost of special and expensive apparatus which the university or other laboratories could not be expected to provide, and which fell outside the scope of the scientific grants made by the Royal Society. The department and the Royal Society work in close co-ordination in this matter. Two outstanding examples of their policy of providing research assistants and special apparatus are the considerable grants paid over a series of years to Sir Ernest (now Lord) Rutherford for his researches with Mr. (now Professor) Kapitza into intense magnetic fields at the Cavendish Laboratory, and to Sir William Bragg for his researches into X-rays, first at University College, London, subsequently at the Royal Institution laboratories, though Sir William Bragg was first assisted on the recommendation of the Physics Co-ordinating Research Board (see below).

Thus the Government was led, by a series of steps which became inevitable directly it called into council a body of expert advisers, to assist our industries to undertake research for themselves in the interests not only of defence but of our sheer survival as a great exporting nation; then to establish and maintain national laboratories for the study of practical problems affecting the nation as a whole; and as the necessary support for both these policies to give direct encouragement and assistance to disinterested research, which finds its natural home in the universities. Since the Treasury, on the advice of the University Grants Committee, makes large grants to all the universities,[1] and since Government itself had established and for many years maintained the Royal School of Mines and the Royal College of Science, subsequently transferred to the Imperial College of Science and Technology in 1907, with a free use of the building and equipment and an annual grant of £20,000 a year, the intervention of the Department of Scientific and Industrial Research in the university field may seem to be untidy if not illogical organisation. The ultimate arrangements, when the nation has reached a full appreciation of the significance of science and of the place of the universities in the national life and economy, may be less disturbing to the tidy mind. Meantime a pressing need had to be met.

CO-ORDINATING RESEARCH BOARDS

It has already been explained that almost from the first Government departments likely to be interested in the plans or work of the department were represented on its Advisory Council or Research Boards by assessors, and in the case of some Boards by full membership. In 1919 the Cabinet formally entrusted the department with the duty of co-ordinating the research work needed for the fighting services so as to avoid unnecessary overlapping, to secure the utmost economy of personnel and equipment, to facilitate the interchange of scientific knowledge and experience between all the departments concerned, and to provide a single direction and financial control of all work of a fundamental nature of civilian as well as military interest.[1] To this end a series of co-ordinating research boards were appointed consisting of responsible technical officers from each of the defence services and any civil departments concerned, together with independent men of science, The boards were to direct any fundamental research required and any investigations having a civilian as well as a military interest. The cost of such work was to be borne by the department even though the work might be done in the establishments and by the officers of another ministry. The department was to secure the assistance of industry and of the research associations in suitable cases. The nucleus of this scheme was already in existence in the Radio Research Board, which had been established in advance of the Cabinet decision at the instance of the Imperial Communications Committee. In addition to this board three new boards were now established to deal with chemistry, physics, and engineering respectively. The plan would not have been feasible but for the increasing extent to which the defence and civilian departments had come to use the facilities offered by the National Physical Laboratory. Its work for the Air Force and for the production of master gauges during the war had been two important factors in a development which has continued ever since. One of the first fruits of the new policy of co-ordination was the erection by the Admiralty in the grounds of the National Physical Laboratory of a Research Laboratory for their own problems in physics (see below).

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[1] For the quinquennium 1926–31 the amount was £1,550,000, for 1931–36 £1,800,000.

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[1] Report of the Committee of the Privy Council for Scientific and Industrial Research. 1919–20. Cd. 905. p. 25.

A great deal of the work for which the co-ordinating research boards became responsible was naturally done at the National Physical Laboratory, but in two directions further laboratory facilities soon became necessary. A Research Station for the study of atmospherics was established on War Office land at Aldershot, but the work was transferred in 1924 to the Radio Research Station at Slough, which had been erected in 1922 in the grounds of the Admiralty Compass Observatory, to deal with directional wireless and the study of the propagation of waves. The work of the Radio Research Board under the chairmanship of the late Admiral of the Fleet, Sir Henry Jackson, has done much in the last ten years to elucidate the theory of the propagation of waves and to provide the necessary data for ascertaining the nature and scope of atmospherics. The Board has secured complete co-operation with the defence services and the Post Office, the Assistant-Engineer-in-Chief to the Postmaster-General being the present chairman of the Board, while it is collaborating equally with the British Broadcasting Corporation and with the radio research organisations in Australia and New Zealand.

A similar development arose from the activities of the Chemistry Co-ordinating Research Board. Though some of the work it undertook could be done at the National Physical Laboratory, a large part of it had to be distributed between other centres with consequent waste of time and lack of the necessary contacts. Accordingly a Chemical Research Laboratory was established at Teddington on land that had been acquired by the Government contiguous to the grounds of Bushy House, and to this laboratory as it became available all the outlying work was transferred.

BRITISH MUSEUM LABORATORY

Lastly, the research stations under the department include the British Museum Laboratory for the preservation and renovation of objects in the national museums and collections. This laboratory was started in 1920 at the instance and with the co-operation of the Trustees of the British Museum who furnished the quarters and equipment, while the department met the cost of maintenance. The purpose in this case was neither military nor industrial, but it was certainly national. The laboratory is being consulted more and more each year by museum authorities as it succeeds in gradually laying sound scientific foundations for work which has traditionally been empirical, and when successful, generally secret. The Museum Trustees are now taking over responsibility for its maintenance.

A list such as this, long as it is, gives no adequate idea of the range of work undertaken by the Department of Scientific and Industrial Research. For that, reference must be made to its annual reports. But it will enable the reader to realise how much has been done to meet that need of greater facilities for the application of science to commerce and manufacture, to which the Prince of Wales called attention when the National Physical Laboratory was opened in 1902. Much still remains to be done by industry itself, and possibly also by the State. Plans for scientific advance call for constant watching and fresh thinking, as the men of science open up new paths, discover new methods, and reveal the possibility of different approaches to old problems. Co-operation with the scientific and technical men in other fields of work, agricultural, medical, and economic, and in other departments of State, must continuously be encouraged and promoted, for the contrary tendencies induced in our administration by the growing pressure of business and by the national *pro domo* spirit will constantly make themselves felt.

Research for the Army, Navy, and Air Force

If the picture of the State's activity in research is to be complete, however, a short account must be added of the principal establishments and laboratories maintained by the defence forces of the country. Although, as has been seen, the first indications of a national interest in science were prompted by the needs of defence, it will not surprise anyone acquainted with our educational traditions to find that the fighting services followed rather than led civilian opinion in recognising the far-reaching possibilities of science. Gunpowder, ballistics, metallurgy, prime-movers, engineering indeed in almost all its branches, aerodynamics, meteorology, the chemistry and physics of explosives and of poison gas, had each in turn claimed their interest and attention. But until after the Great War there was no systematic study of the services science could render, no officer and no staff devoted to the scientific aspect of war, whose duty it was to watch the many experiments made or to study ideas as they emerged—or to produce a plan for bringing together the difficulties and experience of different branches of the service, whether military, naval, or aeronautical.

WAR OFFICE

The War Office has a number of boards and committees responsible for experiment and research, some of which have their own stations or establishments for investigation. The Ordnance Committee, for instance, deals with all matters affecting the efficiency of explosives, ammunition, and guns, on behalf of all three services. It uses the Research Department, Woolwich, the Design Department, and the Experimental Establishment, Shoeburyness, for its research and experiments. But the Research Department, Woolwich, founded in 1904, has far wider duties than this. It is divided into four directorates under civilian scientists of high standing which deal with explosives, metallurgy, internal ballistics, and radiology respectively. It is maintained jointly by the three services and is administered under the Master-General of the Ordnance by a Chief Superintendent, a Deputy-Superintendent (both alternately officers of the army or navy) and four assistant superintendents, who are military, naval, or air-force officers. The work to be undertaken is defined by the Ordnance Committee, the whole-time members of which are combatant officers, or by other branches of the War Office.

The Royal Engineer Board has functions in its own field similar to those of the Ordnance Committee.

Like that committee, it consists of whole-time serving officers and a certain number of civilian associate members who may be called in to assist. Its work is organised under three sub-committees for (*a*) bridging and mining; (*b*) mechanical and electrical equipment; (*c*) signalling apparatus. Representatives of the other services sit on these sub-committees. Connected with the Board are three experimental establishments, one for Signals at Woolwich, one for Air Defence at Biggin Hill, and the third for Experimental Bridging at Christchurch, Hants.

The Chemical Defence Committee is advisory to the Chemical Defence Research Department of the three services. The president of the committee is an officer on the staff of the Master General of the Ordnance, the Vice-president is a naval officer, and the members are seven civilian men of science and three chemical manufacturers. The business, other than policy, is conducted through sub-committees. Attached to the committee for experiment and research are an Experimental Station at Porton, and a Research Establishment at Sutton Oak. Work is also done at the universities and elsewhere.

The Mechanical Warfare Board uses the Design Department, Woolwich, and two small experimental stations at Farnborough and Aldershot. The Small Arms Committee similarly has an experimental station at Hythe, but in the main both this and the Mechanical Warfare Committee depend on close collaboration with industry, with the Design and Research Departments, Woolwich, and with service technical staff. The Royal Artillery Committee has no research establishments of its own and there is no Director of Research at the War Office.

ADMIRALTY

The Admiralty, besides its share in the experimental and research stations described above, had no scientific research department of its own till after the war. A number of research stations dealing with different problems were established during the war but there was no Director of Research till 1920. When this office was established the holder was made responsible to the Controller of the Navy for

- (*a*) The general direction and organisation of research work for naval purposes;
- (*b*) advising as to the programme of research work to be undertaken and as to proposals for specific investigations, and
- (*c*) the efficiency of the organisation for research and experimental purposes of the Admiralty Research Laboratory.

The right relation of the director to the many executive officers responsible for different types of material was not easy to establish, but the problem has been successfully solved with untold gain to the service. The director co-ordinates the annual proposals for research work proposed by the various technical and scientific establishments, advises the Board of Admiralty on them, and allocates the necessary corresponding expenditure on scientific personnel. The scientific staffs of various establishments in which experiment and research are conducted form a single pool and all their reports come to the director. He prepares a list of all researches in progress or proposed, and after a yearly meeting with the heads of the technical departments and the Naval Staff a final list of the work to be done in the coming year is determined by the Assistant Chief of Naval Staff and the Controller in consultation with the Director. That is the organisation in outline. The Director also has under his own control the Admiralty Research Laboratory, in which work is done on basic problems that may affect naval interests and for which there is no suitable provision elsewhere. He has a headquarters staff of three scientific men, a retired naval officer, and technical and clerical assistance.

AIR MINISTRY

The Air Ministry has followed in general the same type of organisation for research as the Admiralty. The Air Council appointed a Director of Scientific Research in 1924 whose functions *mutatis mutandis* broadly correspond to those of his opposite number at the Admiralty. The Ministry's most important committee for research is the Aeronautical Research Committee, established in 1920 to advise the Secretary of State for Air and to supervise the aerodynamic research at the National Physical Laboratory. It took the place of an Advisory Committee for Aeronautics appointed in 1909 to advise the Prime Minister. The Director is a member of the committee which includes representatives of the two other services and of the Department of Scientific and Industrial Research.

The most important research centre of the Ministry, apart from the Aerodynamics Department of the National Physical Laboratory which is almost entirely maintained by them, is the Royal Aircraft Establishment, South Farnborough. Other centres of experimental work are the Aeroplane and Armament Experimental Establishment, Martlesham Heath, the Marine Aircraft Experimental Establishment, Felixstowe, and the Royal Airship Works, Cardington. The Ministry also maintains a laboratory for chemical and physical problems at the Imperial College of Science, while research into seaplane floats and flying boat hulls is conducted at the Froude National Tank at Teddington.

In 1919 the Meteorological Office was transferred to the Ministry in view of the immediate interest of the flying services, both civil and military, in atmospheric conditions. The office was first established in 1854 as a department of the Board of Trade because of its concern with the merchant marine, but in 1867 the Government of the day realising that the development of meteorology must depend on scientific research, invited the Royal Society to appoint a committee to control its work. This arrangement lasted until 1905, when the Treasury became responsible for the committee, which from that date until 1919 consisted of the Director of the Office as chairman, and representatives of the Treasury, the Boards of Trade and Agriculture, and the Royal Society as members. Since its transfer to the Air Ministry it has included representatives of all the departments of Government directly interested, and also of the Royal Societies of London and Edinburgh. It has a subordinate committee which meets in Edinburgh.

The travels of the Meteorological Office during the second half of the last century and the early part of this, from its maternal home the Board of Trade, *via* the Royal Society and the Treasury to the Air Ministry, are indicative of the hestitating action induced by unscientific administration. There were, no doubt, admirable reasons of administrative convenience for transferring the Office from the control of the Royal Society to the Treasury, and from the Treasury to the Air Ministry. But the interest of a particular department or departments in using the results obtained by a scientific service, or in seeing that its money is well spent, are no valid reasons for putting those departments in control; particularly when, as in this case, the future usefulness of the service depends upon the extent to which fundamental research is encouraged. Administrative departments of State have little use for the exploration of basic principles.

It has been pointed out already that in 1920 the Cabinet took important steps to co-ordinate the research work of the several defence services with that going on for industrial purposes by the appointment of co-ordinating research boards in the Department of Scientific and Industrial Research. These boards undoubtedly did useful work and established such close links between the scientific services of the departments concerned that, with the exception of the Radio Research Board, which has come to be the centre for most of the fundamental research in wireless undertaken by Government, it has not been necessary to continue their existence as a means of co-ordination. The Chemistry

Research Board, however, which has taken the place of the Chemistry Co-ordinating Board and controls the work done in the Chemical laboratory, includes assessors from the three services and similar provision is made for co-operation on other boards and committees in the department.

RESEARCH IN NATIONAL MUSEUMS

Finally, it must not be forgotten that a large amount of scientific research is going on in the national museums, including, so far as concerns London, research in archæology and ethnology at the British Museum, Bloomsbury; in zoology, entomology, botany, geology, and mineralogy at the British Museum (Natural History), South Kensington; in geology with an economic outlook at the Museum of Practical Geology, Jermyn Street. These institutions are dealt with in Chapter IX.[1]

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[1] For much of the information in this historical sketch the author is indebted to the Report of the Research Co-ordination Sub-Committee of the Committee of Civil Research published in 1928, and to the series of Annual Reports of the Committee of the Privy Council for Scientific and Industrial Research. Reference may also be made to the presidential address of Sir Robert Robertson, K.B.E., F.R.S., to Section B of the British Association Meeting at Toronto, 1924, on *Chemistry and the State* (Report of the British Association, 1924), and to *The Government and the Organisation of Scientific Research*, a paper read by the author before the Royal Society for Arts, 1919 (*Journal* of the Society, vol. LXVII, pp. 206-19).

CHAPTER VI

THE ROYAL OBSERVATORY, GREENWICH

By SIR FRANK DYSON, KT., K.B.E., F.R.S.

THE Royal Observatory was founded at the instance of Charles II for the assistance of navigation, especially in the difficult problem of determining the longitude of a ship at sea. The first stone was laid on August 10, 1675. An idea had been promulgated that the moon, which goes round the sky in a month, should serve as a clock giving Greenwich time. If astronomers could produce an almanac predicting the exact position of the moon among the stars the navigator would possess a means of determining Greenwich time, and by subtracting this from local ships' time could determine his longitude. The difficulty of the problem was hardly realised at the time, but as Newton had shown how the movements of the moon were to be calculated, the time was ripe for an observatory, though it was many years before the co-operation of mathematical and observational astronomers made it possible to determine longitude at sea.

The astronomers, Flamsteed, Halley, Bradley, and Maskelyne,[1] carried on observations of the sun, moon, planets, and bright stars till the end of the eighteenth century, and continuously added to the accuracy of our knowledge of the positions and movements of these bodies. Gradually, with the assistance of mechanicians and opticians, they improved the instruments. They also made important astronomical discoveries. Halley discovered that the comet he had seen had visited the earth seventy-five years previously, and again seventy-five earlier, and predicted its return in 1759. Since then it has been seen in 1835 and 1910. Bradley discovered 'aberration,' *i.e.*, change in the apparent position of the stars due to the fact that light does not travel with infinite velocity but only 186,000 miles a second. In this way he was able to compare the velocity of light with the velocity of the earth in its motion round the sun. Maskelyne weighed the earth by determining how much the mountain Schiehallion (Perthshire) disturbed the vertical, and so compared the attraction of the earth with the attraction of the mountain. In Maskelyne's time the determination of longitude was greatly facilitated by the invention of the chronometer. A prize of £20,000 offered by the British Government was won by John Harrison (1693-1776), a carpenter of Hull and a great mechanical genius, after a life-time of effort.

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[1] John Flamsteed (1646-1719), first Astronomer Royal, Edmund Halley (1656-1742), James Bradley (1693-1762), Nevil Maskelyne (1732-1811).

In the nineteenth century the work of the Observatory was re-organised and extended by Sir George Biddell Airy (1801-92). He introduced regular magnetic and meteorological observations and obtained new and larger instruments. The telegraphic distribution of time from Greenwich was initiated by him, a matter of importance after the construction of railways. Christie brought in more large telescopes and added considerably to the scope of the Observatory by the introduction of photography, which in his time had become of great importance in astronomy.

Many different branches of astronomical and other work are carried out at the Greenwich Observatory. The determination and distribution of time from Greenwich through the British Broadcasting Corporation is well known. In addition, Greenwich time is sent twice a day from the powerful station at Rugby and reaches all parts of the world, and in the United Kingdom telegraphic distribution is maintained through the General Post Office. The Observatory—a branch of the Admiralty—and in close touch with the Hydrographic Office, sees to the repair and timing of naval chronometers, and prepares charts showing the deviation of the magnetic compass from true north. Regular meteorological observations are also carried out. The more strictly astronomical work carries on the traditional work of determining the positions of the sun, moon, planets, and stars. The importance of this for navigation has largely ceased, but many important scientific questions still require and will probably always require continuance of these observations. When one problem is solved another arises. Then the small movement of the axis of the earth is regularly under observation. Photography constantly carried on gives increase of our knowledge of the movements of many thousands of comparatively faint stars. With one of the largest telescopes the distances of 400 stars have been measured in recent years as the result of 10,000 photographs. Another large telescope with a spectroscope attached has determined the temperatures of many of the brighter stars. A large visual refractor is used for the measurement of double stars, observations which teach us, among others things, how massive the stars are as compared with the sun or the earth. In the daytime the sun is regularly photographed and its spots measured both in size and position. In this way we learn how the sun rotates, and find that the condition of the sun is connected in a very curious way with magnetic phenomena. The magnetic observations have been transferred from Greenwich to an outpost at Abinger, Surrey, since the electrification of the railways, which disturbed the observations.

CHAPTER VII

KEW GARDENS AND THE JOHN INNES INSTITUTION

THE ROYAL BOTANIC GARDENS, KEW

By the late T. F. CHIPP, M.C.[1]

THE Royal Botanic Gardens, Kew, are almost unique among botanical institutions in having had no connection with a university or educational establishment. Private gardens at Kew had been far-famed for many years when Princess Augusta of Saxe-Gotha, widow of Frederick, Prince of Wales, started a botanic, or as it was then called, a physic, garden in 1760, on an area of some nine acres. After her death George III united the properties of Richmond Lodge and Kew House. These properties, with certain subsequent modifications, constitute the gardens of the present day. George III, with the eminent scientist, Sir Joseph Banks, as botanical adviser, raised the botanical status of Kew to a position of world-wide importance. After the deaths of George III and Banks, royal interest in Kew declined and by 1837 the existence of the gardens had become precarious. A committee was appointed to enquire into the position, and as a result the gardens became, in 1841, a national institution, Sir William Hooker being appointed the first director.

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[1] The thanks of the editor are due to the Director of the Royal Botanic Gardens, Sir Arthur Hill, K.C.M.G., F.R.S., for revising the proofs of this chapter after the lamented death of its author.

As constituted at the present day the Royal Botanic Gardens are divided into several departments. The gardens themselves, which are best known to the public, are organised in five sections:—the arboretum, the rock garden and herbaceous grounds, the flower garden and decorative department, and the temperate and tropical departments. The four museums of Economic Botany are also open to the public. The library and herbarium and the Jodrell Laboratory are reserved for research and open to botanists.

The gardens are primarily a botanic garden where trees, shrubs, and other plants have to be grown for purposes of study and comparison, often without regard to their value in the landscape. In spite of this fact, and in spite of the proximity of gas works and factories, and the flat surface and dry, hungry soil, Kew is a typical English garden, characteristic of the country. In a setting of spacious and shady lawns, set out with specimen trees and broken by vistas and patches of woodland, there are numerous small gardens each with its own individual character. Thus collected together may be found the irises, bamboos, rhododendrons, azaleas, plants of the heath family, the hardy ferns, roses, etc. Examples of the English countryside are seen in the wild gardens around the Temple of Aeolus and in the Queen's Cottage Grounds; whilst formal gardening is seen in Cambridge Cottage garden, and in the Italian garden near the Palm House. In the Alpine House may be seen early alpine flowers which later are found in the rock garden. Water plants can be studied in the Aquatic

Garden, whilst waterside effects are seen around the pond, the lake, and the various lily ponds. Collections of plants of a more definite botanical interest can be seen in the Herbaceous ground and in the Medicinal Garden close to Museum IV.

In the glass-houses plants have to be grouped according to the conditions required for their successful cultivation. Tropical vegetation is represented in the Palm House, the Aroid House, the Tropical Ferneries, houses devoted to aquatics, begonias, stove plants, pitcher plants, orchids, etc. The temperate flora, representative chiefly of South Africa, Australia, New Zealand, and China, is to be found in the Temperate House, the Cape House, and the houses devoted to temperate ferns and insectivorous plants. Succulents are accommodated in House No. 5; new and well-known decorative plants in the Conservatory. Two houses are devoted to tropical economic plants.

The remaining outstanding feature of the gardens is the comprehensive and extensive arboretum. Here examples of all trees and shrubs hardy in this part of England, are grown grouped according to their natural affinities, in proper botanical sequence, yet fitting into the general landscape effect.

The many architectural features are a survival of the Georgian times. The most striking is the Pagoda, 163 ft. high, designed by Sir William Chambers and erected in 1761. The flagstaff, a fine specimen of Douglas Fir from British Columbia, 214 ft. high, was erected in 1919. The gardens were first opened to the public in 1841, when 9,000 people attended. In 1930 the attendance totalled 1,544,212, the largest number on any one day being nearly 98,000.

The four museums of Economic Botany house the varied and extensive collections of plant products from all parts of the world. Two of these buildings contain specimens of plant products generally; one is devoted to colonial and foreign timbers, one to home-grown timbers. The chief object of these museums is to show the practical application of botanical science, to enable students and those engaged in commerce, both at home and from overseas, to appreciate the general relations of the vegetable world to man, and to exhibit the vast material resources of the Empire.

The laboratory, presented by Mr. Phillips Jodrell in 1876, is devoted to physiological and anatomical research.

Accredited students are welcomed and facilities are given them to conduct their own research. The library and herbarium are contained in one building near the main entrance on Kew Green. The library is the finest of its kind. In addition to many thousands of volumes, there is a comprehensive series of the botanical periodicals of the world and a magnificent collection of botanical illustrations.

The herbarium contains some four million dried specimens of plants from every part of the world, but representing especially the vegetation of the British Empire. In addition there are separate biological and genetical herbaria and a large collection of authentically named seeds. The principal work of this department is the systematic investigation and description of the floras of the British Empire. Every facility for research is given to persons duly accredited, and the herbarium is seldom without visitors from the various botanical institutions of the world.

Although not in any sense a teaching institution, Kew provides a training place for young student gardeners, of whom there are about forty. They remain at Kew for a period of two years and undergo a course of practical work which is supplemented by lectures in the sciences underlying horticulture. This aspect of the work of the institution originated in Sir Joseph Banks' policy of sending out Kew-trained men as collectors, which led to Kew becoming the centre of botanical exploration and experiment from the time of its establishment as a national institution.

Botanic gardens have arisen in different ways and from different interests, but so far as the Empire is concerned the underlying motive in nearly every case has been the distribution of plants likely to prove of economic value. Kew has become the centre of a network of these botanic gardens, or as they are now generally termed in the tropics, agricultural stations, by which the general interests of the different parts of the Empire are served. The work of Kew has reference to the appointment of staffs, the policies to be pursued, the prosecution of research, the introduction and exchange of plants of economic importance, the compilation of floras, and guidance in the early development of crops of importance. In brief, Kew may be described as the central exchange and clearing house of the Empire for all botanical information and material.

THE JOHN INNES HORTICULTURAL INSTITUTION

By SIR DANIEL HALL, K.C.B., F.R.S.

This Institution was founded under the will of the late John Innes, who died in 1904. The scheme of the Charity Commissioners under which the institution is administered is dated January 12, 1909, and the institution began work in the following year.

John Innes was a merchant of the City of London, who, having purchased a piece of land in Merton, enlarged and came to live in the Manor House and proceeded to develop the Merton Park estate. John Innes was a liberal benefactor to the district; he built the Working Men's and Boys' Clubs and the Freemasons' Hall, and aided in the foundation of the Rutlish School. In addition to the institution his will provided for the creation of a public park and recreation ground, for scholarships to the Rutlish School, and sums for the maintenance of the Boys' Club and other local charitable objects.

The institution is administered by a council consisting of three trustees and nine members appointed by the Ministry of Agriculture and Fisheries, the Royal Horticultural Society, the Fruiterers' Company, the National Fruitgrowers' Federation, the Universities of Oxford, Cambridge and London, and the Imperial College of Science and Technology. The income derived from the Trust Funds is upwards of £20,000 per annum.

The objects of the institution are 'to carry out investigation and research whether of a practical or scientific nature, into any matters having reference to the growth of trees and plants generally.' The first director was William Bateson, who inaugurated the establishment and worked here until his death in 1926. Bateson was then in the full tide of his investigations in the science of genetics, which he had done so much to create, and he left Cambridge for Merton because of the opportunities it offered of growing plants on a large scale. Bateson soon gathered a body of young workers round him, and from this impetus the work of the Institution is still primarily concerned with the genetics and cytology of plants and with such physiological and pathological work as bears upon plant breeding. An important section of work is concerned with the study of the breeding and fertility of fruit trees (apples, plums, cherries, Rubi, and strawberries in particular). Certain horticultural problems dealing with the breeding and cultivation of garden plants are also under investigation. The institution also admits each year six student gardeners, who have four years' previous experience in a garden, for a course of two years' training. These student gardeners, who are given a living allowance, receive a practical training by participating in the routine of each of the departments of the gardens of the institution, outdoor and indoor, and attend courses of lectures delivered by members of the staff on elementary science, systematic and physiological botany, the chemistry of plants and soils, plant breeding, etc. Two greenhouses are reserved for instruction in the cultivation of specimen plants and commercial plant breeding.

The institution is situated at Merton, about one mile from Wimbledon station. It possesses two gardens of about 12½ and 2½ acres respectively. The buildings embrace three main biological and one chemical laboratory, various smaller laboratories, and preparation rooms, a library, photographic studio, and dark rooms. There are seven experimental greenhouses in addition to the two devoted to instruction, a tulip house and fern house, and a small insectarium.

CHAPTER VIII

THE DEVELOPMENT OF MEDICINE IN LONDON

By H. H. BASHFORD, M.D.

IT has been suggested, not unreasonably, that men who had consulted Galen about their health in the second century A.D. may have paused upon the Roman causeway in Cheapside and compared their experiences in the great Pergamene's consulting-room. Some of his pupils, indeed, may even have been practising in the London of that day. But with the departure of the legions there faded from Britain, as afterwards from the rest of the crumbling empire, not only all knowledge of the master's teaching, but also of the brilliant methods upon which it had been founded. Some of it returned, no doubt, in a debased and legendary form, with Augustine and his fellow missionaries, together with a considerable infusion of Oriental magic, more or less modified by Christianity. Traces of both, mingled with an indigenous herbal lore, are at any rate to be found in the *Leech Book* of Bald, written in the vernacular soon after the death of Alfred the Great, and the earliest surviving medical treatise compiled in these islands.

There had been preserved in the East, however, a rather purer tradition of the comparatively advanced Galenic Greek medicine, and this began to flow westwards again in the wake of the great Mohammedan invasion. It was accompanied by the teaching, some of it very valuable, of the leading Arabian and Persian physicians; and these were the main elements of which our island medicine, such as it was, consisted at the time of the Norman Conquest. As for its practitioners, apart from the herbalists, wise women and the like, scattered over the country, these were, of course, chiefly clerical. Bald and Cild, who compiled the Anglo-Saxon *Leech Book*, were themselves probably native monks. And although an inferior order of *medici* or leeches may be divined from the pages of Bede—and were probably still engaged in practice at the coming of the Normans—the average island doctor, both then and for the next two or three generations, was doubtless some local priest.

Many of these, perhaps most, would have been educated at home and were still ignorant of French. But attached to the court and the castles of the principal Norman nobility, as well as in most of the larger towns, were foreign-born and continentally-educated physicians of a somewhat more erudite type. Such were Gilbert Maminot, Bishop of Lisieux, physician to William the Conqueror, and his colleague, Abbot Guntard of Jumièges. But no great figure is to be found amongst them; the few that have emerged are little more than names; and until the coming of such orders as the Benedictines and the Augustines—of whom Jacobus de Vitry has told us that they bore 'for Christ's sake the filth and impurities of the patients, and the annoyance of almost unbearable smells'—there was but little organised treatment of the sick.

It was not until 1123, indeed, in the reign of

Henry I, that the first of the great general hospitals appeared in London, built in conjunction with, but fortunately independent of, the Augustinian Priory of St. Bartholomew. It was founded by Rahere, of whose early life very little is known, although he seems to have commended himself by his gaiety and wit to the influential circle surrounding the King. As the result of a change of outlook, however, he made a pilgrimage to Rome; and it was upon his return, in the fulfilment of a vow, that he established in Smithfield the beginnings of the hospital that has remained there ever since.

Smithfield was then an open ground outside the northern wall of the city, a site for a horse fair and general recreation, and beyond it were farm-lands under tillage stretching to an unenclosed area of forest and wild game. Though he met with a certain amount of opposition, Rahere had good friends, and he saw the completion of both his priory and his hospital, with its eight brethren and four sisters. It soon established itself in the affections of Londoners. The City's first mayor was one of its most ardent supporters, and it began to accumulate endowments from the nobility and London's wealthier citizens. It was also accorded certain other privileges; and in 1350, during the reign of Edward III, it received a remission of various taxes, owing to the high cost of the services it was rendering. These included, besides the succour of general patients, the care of lying-in mothers until they were well enough to go about their work again, and in some cases the maintenance of orphaned children till they were seven years old.

By then London had become a town of some thirty thousand inhabitants with varied and prosperous markets. The outlying villages of Strand and Holborn were beginning to be fashionable resorts; and, apart from St. Bartholomew's, there were about a dozen hospitals in London and its suburbs. Of these the two leper hospitals of St. Giles-without-Bishopsgate and St. James, Westminster, were as old as, or a little older than, St. Bartholomew's. The hospital of St. Katharine-by-the-Tower had been founded some twenty-five years later. Prior Richard of Bermondsey had established St. Thomas's hospital early in the thirteenth century, in what was afterwards High Street, Southwark. In 1247, where Liverpool Street Station now stands, Simon Fitz Mary had founded a priory for the Bethlehemites, with an attached hospital, dedicated to St. Mary of Bethlehem, destined to be London's first refuge for the insane. And in 1331 William Elsing, a benevolent mercer, had established the first hospital for the blind at St. Mary-within-Cripplegate.

Meanwhile, there had appeared at Oxford the beginning of a medical school, so that it was no longer necessary for a would-be English physician to depend upon such training centres as those at Salerno or Montpellier. The teaching was, of course, mainly academic, but seems to have been fairly exigent. A master of arts was obliged to study for four years before being able to qualify in medicine, and he was expected to conduct arguments upon such treatises as the *Regimentum Acutorum* of Hippocrates, the *Liber Febrium* of the centenarian Jewish physician, Isaac, and the *Antidotarium* of Nicholas

Praepositus, the standard pharmacopœia of the time. On the practical side, however, it was decidedly sparse; and it was apparently possible to have graduated at Oxford without having performed a dissection or seen a patient.

Hailing from this school was the virile and amusing court physician, John of Gaddesden, whose *Rosa Medicinæ* was one of the earliest and most famous of English medical text-books. John was an old man in 1350 but had been one of London's most fashionable doctors—he is said, indeed, to have been the original of Chaucer's physician in the *Canterbury Tales*—and his book is a curious mixture of commonsense and absurdity, of borrowed Arabian and Greek aphorisms, and naïve advice as to how a physician may extract money from his wealthier patients.

London had also been responsible, in the birth of the Barbers' Guild, for the first loose organisation of the profession of surgery. This consisted of an association of barbers and barber-surgeons, whose first master had been sworn at the Guildhall in 1308. Independent of this and somewhat later in origin, was another and smaller Guild of Surgeons, considering itself superior to, but not so politically powerful as, the Guild of Barbers. Since physicians seldom condescended to perform surgical operations—though John of Gaddesden seems to have been a criticised exception—it was by apprenticeship to members of these two guilds that the art of surgery was officially maintained.

But there were no hard and fast rules, as John of Gaddesden illustrates, since he appears to have been quite willing, provided he were paid for it, to draw his patients' teeth, cut their corns, or even kill their lice. Moreover, there was a host of totally unqualified and ignorant practitioners; and in 1421, during the reign of Henry V, there was passed the first law regulating the practice of medicine and surgery in England. It was not so precise as its sponsors had hoped. But Parliament ordained that the Lords of the King's Council could impose penalties on irregular practitioners, that is to say, upon all who had not graduated at some recognised university or served as pupils under master surgeons.

A further advance was made by the Guild of Barbers when it obtained a Royal Charter of Incorporation from Edward IV in 1462. This admitted it to the ranks of the great city companies and contained the definite enactment that nobody was to pursue the guild's craft in London or its suburbs unless examined and approved by the masters. That was two years after the birth at Canterbury of the next great figure in English medicine, Thomas Linacre, who was to achieve for the physicians something of the unity being acquired by the surgeons. Educated at what was afterwards known as the King's School, Canterbury, under the sympathetic eye of the enlightened Prior Selling, Linacre upon leaving Oxford studied in Italy, then in the full blaze of the Renaissance. Together with his two great friends, William Latimer and Grocyn—the distinguished Wykehamist, who was afterwards rector of St. Lawrence Jewry—he became a pioneer in England of the study of Greek and the new learning that was transforming Europe.

It was of Linacre that Erasmus wrote: 'he is as deep and acute a thinker as I have ever met with,' and apart from his qualities as a physician he had an obvious genius for friendship. Coming up to London from Oxford rather late in life, he settled at the Stone House in Knightrider Street; and at the age of forty-nine, when he became physician to Henry VIII, most of the statesmen of his time—men such as Cardinal Wolsey, Archbishop Warham, Cuthbert Tunstall, and Thomas More—were not only his patients but his intimate companions.

It was to Wolsey, then at the height of his power, that he dedicated his translation of *Galen on the Pulse*, and this was only one of many restorations into a masterly Latin of the original Greek texts that had just been brought to light. It was probably upon these that his contemporaries assumed his fame would rest. But the domination of Galen over medical thought, though it had been immensely strengthened by the Renaissance discoveries, was not to remain unchallenged much longer. And if Linacre is remembered to-day, it is principally because he was the founder of the Royal College of Physicians.

This took place in 1518, thanks to Linacre's influence at court, and it consisted in the first place of six physicians meeting under his presidency at his own house. They were all men of high attainments. Including Linacre three of them held court appointments; and they were formed into an examining body with powers to demand a reasonable standard of efficiency. Without their approval nobody other than a medical graduate of university standing was allowed to practise physic in the City of London or within a seven-mile radius; and five years later their jurisdiction was extended to the whole country. It was a measure that was opposed by many of the bishops, who had just been given the curious right, under an Act of 1511, of sanctioning the practice of medicine and surgery in their several dioceses. But it was an admirable and successful piece of legislation. It not only helped to free medicine from ecclesiastical control, but it created a clearing-house for medical ideas, and acted as a check upon the widespread and dishonest exploitation of the public. When Linacre died in 1524, he bequeathed the Stone House in Knightrider Street to the college, and thus for the first time medicine had a headquarters comparable with that of surgery at the Barbers' Hall in Monkwell Street.

While all this was proceeding, however, the hospitals of London were approaching a crisis that was to be fatal for most of them. Associated as they were with various religious orders, and generally attached to monastic buildings, they had been steadily growing in numbers and wealth. In the year 1535 there were two richer than St. Bartholomew's, the hospital founded in the Savoy by Henry VII, and the Hospital of Our Lady outside Bishopsgate which had 180 beds. St. Bartholomew's ranked third, St. Thomas's fourth, the fifth being the Hospital of St. Mary in Aldermanbury. But with the dissolution of the monasteries in 1536 the old order of hospitals came to an end. More than a hundred disappeared in all parts of the country, and although the relief of the poor had been vaguely transferred to local municipal authorities, there followed a period of great suffering amongst those whom the religious orders had previously succoured.

This was so acute in London that the Lord Mayor, Sir Richard Gresham, appealed to the King for the immediate resuscitation of some of the London hospitals, notably St. Bartholomew's, St. Thomas's, and St. Mary of Bethlehem. Thanks to its independence of the associated Augustinian Priory, the site of St. Bartholomew's Hospital had remained unsold, though the hospital itself had languished uncared for; and after some delay it was reconstituted. During the next few years the words steward, matron, and sisters appear upon its records. A whole-time physician, who was a Fellow of the new Royal College, was appointed, and arrangements were made for the daily attendance of three qualified surgeons. The Hospital of St. Mary of Bethlehem, or Bedlam, was also restored as an asylum for the insane; St. Thomas's Hospital was established again in Southwark; and by a charter of 1553, all three were placed under the perpetual governance of the Lord Mayor and Commonalty of the City of London. They were generously supported by the great City Companies and many private benefactors, and remained the only important hospitals in London until the end of the seventeenth century.

During this period there had been a further consolidation, too, among the London surgeons. Negotiations had taken place between the barbers and barber-surgeons and the smaller, outside Guild of Surgeons; and in 1540 the two had been blended into a single company. Known henceforward as the

Masters and Governors of the Mystery and Commonalty of Barbers and Surgeons in London, their first master was Thomas Vicary, who was also one of the governors of St. Bartholomew's Hospital, and they were given the right to dissect, each year, the dead bodies of four malefactors. Later these dissections were placed under the supervision of two Masters and two Stewards of Anatomy; and in 1563, during the reign of Queen Elizabeth, the Royal College of Physicians received a similar privilege.

This was largely due to the influence of John Caius, the second founder of the college named after him at Cambridge—an eccentric old bachelor who had been physician to Edward VI and Mary, and was probably the ablest figure in English medicine since the death of Thomas Linacre. He was a profound classical scholar. He had set the highest of standards as a lecturer on anatomy at the Hall of the Barber-Surgeons. Over and over again he had been elected President of the Royal College of Physicians, but as a devout Catholic he had regarded the coming of Protestantism as disastrous alike both to morals and to manners. Growing old, he could not but deplore the freedom of manners at the universities, and as for the new generation of children—presently to be the defeaters of the Armada—they were being 'so brought up,' he records, 'that if they be not all day by the fire with a toast and butter and in their furs they be straight sick.' Ultimately he retired to his little house, one of twenty in Bartholomew Close, and, jealously guarded by a single servant, ended his days in 1573.

From a study of the literature it would seem clear that every rising generation in England has exhibited signs to its elders of a disturbing softness. But the particular generation despaired of by Caius was not without elements of vigour. It included, or was about to include, Hawkins, Drake, Frobisher, Gilbert, Walter Raleigh, Sidney, Spenser, Francis Bacon, Christopher Marlowe, and Shakespeare. Five years after he died, too, there was born at Folkestone, in a typical Elizabethan yeoman household, the boy who was to open as new a world to the eyes of medicine as the Elizabethan sailors to those of geography. This was William Harvey, and when he was born Drake in the *Pelican* was making the first English voyage round the globe, Bacon was reading for the Bar, and Shakespeare and Marlowe were boys of fourteen; and it is pleasant to recall that, at the age of fifteen, it was Caius College that welcomed him to Cambridge. From there he went to Padua, then the principal European school, studied anatomy under the famous Fabricius, became interested in the heart and blood-vessels generally, acquainted himself respectfully with Galen's theories about them, was not quite satisfied that they explained the facts, took a brilliant degree, and returned to England. He then fell in love with Elizabeth Browne, the daughter of one of Queen Elizabeth's physicians, and at twenty-six settled into general practice at a house in the parish of St. Martin-extra-Ludgate.

He was then a little dark-eyed, quick-tempered man, but of a disarming candour and friendliness, and his outstanding abilities were soon recognised.

In five years he had become a member of the College of Physicians and an Assistant Physician at St. Bartholomew's, but the problem that had stirred him in Italy had never been forgotten. Whenever he had time he was experimenting, testing and re-testing his conclusions; and in April, 1616, as has been mentioned in an earlier chapter, he was able to announce, in his discovery of the circulation of the blood, the greatest single achievement, perhaps, in the history of medicine.

By then Linacre's old house in Knightrider Street, although a new theatre had been added, had been found too small for the growing college, and in 1614 new premises had been rented from the Dean and Chapter of St. Paul's at Amen Corner, close to Paternoster Row. And in 1617 there was a further development in the crystallisation of English medicine. The apothecaries, who had hitherto been embraced by the powerful Grocers' Company, succeeded in making themselves, thanks to the support of James I, an independent body. This was to ensure, they said, a greater purity in the provision of drugs, since 'many Empiricks and unskilful and ignorant Men .... do abide in our City of London'; and although a few years later, backed up by the House of Commons, the grocers nearly managed to revoke the seceders' charter, the King stood firm, and in due course the Society of Apothecaries became a fully recognised and established City Company. For the sum of £1,000 it bought Cobham House in Water Lane upon the banks of the Thames, and this was formally opened as the society's hall in 1632. At the same time the standards required for qualification were considerably raised. Physicians were appointed to attend its examinations. And since its members were allowed not only to dispense but prescribe, the society became, to all intents and purposes, an authority admitting to general practice—a privilege that it still retains. Thanks to the generosity of Harvey, too, the buildings of the Royal College of Physicians were soon to be greatly enlarged. A museum and library were built and furnished, and in 1653, after a royal entertainment to the Fellows, the old man, who had refused to become their president, presented them with the title deeds.

But the Great Fire of 1666 was to take a heavy toll of them all. With the Norman and Gothic cathedral of St. Paul's, eighty odd churches, and over 13,000 private houses, there disappeared the Physicians' building in Amen Corner, the whole of the Barber-Surgeons' Hall in Monkwell Street, with the exception of the theatre and the court room, designed by Inigo Jones in 1630, and the Apothecaries' Hall at Cobham House. All were rebuilt, of course. The new building of the Royal College of Physicians, designed by Christopher Wren and Robert Hooke, was opened in Warwick Lane in 1674. The barber-surgeons repaired their ruins in Monkwell Street, where the Barbers' Hall is still to be found, and the apothecaries sold their plate, let their adjacent burnt tenements on a building lease, and began at once to lay the foundations of their present home in Water Lane.

They also began to look about for a garden in which their members and pupils might study botany, medical and otherwise, and in 1673 acquired from Charles Cheyne, afterwards Lord Cheyne, the lease of three and a half acres on the river bank at Chelsea. Chelsea was then a village beyond the River Westbourne, now imprisoned in an underground conduit save for the few yards that still trickle from the Serpentine to disappear under Rotten Row. It was also a place of great houses, the manor-house built by Henry VIII and afterwards bought and occupied by Sir Hans Sloane, the palace of the Bishops of Winchester, Beaufort House, the home of Sir Thomas More, and several others. These have all vanished. But the little Chelsea Physic Garden remains, with its original gates of wrought Sussex iron, though it is parted from the river that once flowed under its banks by the present Chelsea Embankment. It was from this garden that the first cotton seeds were sent out to Georgia in 1732. For many generations it remained, and indeed is still, a resort for students; and it was finally bought and presented to the Society of Apothecaries by Sir Hans Sloane, the first medical baronet, physician to George I and George II, and the founder of the British Museum.

In his younger days Sloane had himself studied there, and both in his many-sidedness and his wealth he was typical of the physicians that flourished in London during what has been called the Golden Age of English medicine. It was the generation that succeeded Sydenham, of whom Sloane was a pupil; and although none of them attained the stature of the grim old Puritan, who had once been a subaltern of Roundhead horse, they were a singularly able group.

Included among them were Garth and Arbuthnot, better remembered now as men of letters, the irascible Radcliffe, founder of the infirmary at Oxford, and Richard Mead, the foremost physician of his time and a discriminating collector of what are now old masters. Though many of them dealt in secret prescriptions, and most of them amassed very considerable fortunes, their traditions were high, especially with regard to their treatment of the poor.

They may be said to coincide, indeed, with the great dispensary and hospital movement that began in the eighteenth century, and most of them were active in its support. It was Mead's influence upon the bookseller, Thomas Guy, who had made a fortune out of South Sea stock, that was largely responsible for the founding of Guy's Hospital. This was opened in 1724, close to St. Thomas's, which had been rebuilt a few years earlier; and Hans Sloane was as intimately associated with the early days of St. George's. This was an off-shoot of the Westminster Dispensary, founded in 1719 and afterwards the Westminster Hospital; and it was in 1733 that St. George's was established at Lanesborough House in Knightsbridge. Before 1760, too, the London Hospital in Whitechapel, Queen Charlotte's Hospital for Women in Marylebone, and the Middlesex Hospital, had all come into being.

There had also taken place in 1745 the separation of the surgeons from the barbers. Henceforward, under their special Charter, they were to be known as the Masters, Governors, and Commonalty of the Art and Science of Surgeons of London—a title retained till 1800 when they became the Royal College of Surgeons of London—and a new hall was designed for them in the Old Bailey by the able and versatile Cheselden. Before the advent of John Hunter, then a lad of seventeen wandering about his mother's farm at Long Calderwood, near Glasgow, Cheselden was probably the greatest surgeon that England had produced. Since 1718 he had been upon the staff of St. Thomas's. In 1733 he became one of the first surgeons to the newly-founded St. George's. He had devised a classical operation for the extraction of stone from the bladder, which he had once performed in fifty-four seconds—an important asset in pre-anæsthetic days. He was a patron of the King, and besides designing the new Surgeon's Hall had been the architect of Putney Bridge.

But it was John Hunter who was to transform English surgery and turn it from a trade into a profession, though less perhaps by his own actual achievements than the great philosophy of observation, experiment, and deduction, with which he inspired his students. Associated for many years with the school of anatomy, founded by his elder and scarcely less famous brother, William, he became a Master of Anatomy to the Company of Surgeons in 1753, a Fellow of the Royal Society in 1767, and in 1768 one of the senior surgeons to St. George's Hospital. He was then forty, and for the rest of his life his activity was prodigious. Ranging over the whole field of natural history, he linked up surgery, as nobody had done before him, with the study of vital processes in every kind of animal. He laid the foundations of our knowledge of animal heat. He was the first to discover and lay bare the course of certain of the cranial nerves, and the first to demonstrate the power of the gastric juices to digest the stomach after death. He introduced an operation for the ligature of aneurysms that saved many hundreds of lives, and behind his house at Leicester Square—next door to Hogarth's widow and opposite Sir Joshua Reynolds—he built up the great museum that is now one of the chief glories of the Royal College of Surgeons in Lincoln's Inn Fields, as further detailed in the following chapter. More than any man, too, he raised the status of surgeons throughout the world; and with the exception of Jenner, one of his pupils, it was the surgeons rather than the physicians—men such as Abernethy, Astley Cooper, Anthony Carlile, Cline, and Blizard —who dominated the medical world in the next generation.

In 1793 Hunter died, on the day that Marie Antoinette went to the guillotine; and with the close of the eighteenth century, ending as it did upon the note struck by the French revolution, there began a new and closer relationship between medicine and the State. The century had already witnessed, in its last two or three decades, a further development in London of the dispensary system. Amongst others there had been established for the help of the sick poor, the Eastern Dispensary in Leman Street, the Finsbury Dispensary, the Marylebone Dispensary, the Surrey Dispensary, the Western Dispensary, Westminster, and many of these still survive.

But medicine was still predominantly individualistic. Fashionable physicians such as Sir Hans Sloane treated the poor for nothing in their own consulting rooms; and immensely valuable as were the services of the hospitals and dispensaries—the former owing a great deal in the way of improved hygiene to the efforts of John Howard, whose life had been contemporary with Hunter's—it was upon the charitably disposed that they mainly depended. Equally individualistic was the education of medical students. There was no central body to inquire into the preliminary education of candidates, and there was no central body, or register, to keep a list of practitioners and their qualifications. For the study of anatomy, physiology, and botany, the London student had to depend upon private schools such as the one in Windmill Street, where William Hunter had taught so many future doctors. Passing from these the student would then apprentice himself to some individual physician, surgeon, or apothecary; and although the germs of medical schools had appeared at the London and Guy's in 1741 and 1769, and students were able to see cases at such hospitals as St. George's, St. Bartholomew's, and St. Thomas's, they did so as the pupils of particular men to whom they were attached and who received their premiums.

Finally, the beginnings alone of preventive medicine, in the modern sense of the word, appeared. It was true that as a port there were regulations designed to protect London from the entrance of epidemic diseases from abroad; and as a result of such Improvement Acts as that of Westminster in 1762 and the City of London in 1766, the paving and lighting of streets had been taken in hand and some elementary drainage begun. But of a sanitary service, such as we know it to-day, London was wholly innocent.

The first medical event in London in the new century was the metamorphosis in 1800 of the Surgeons' Company into the Royal College of Surgeons of London, followed by its removal to Lincoln's Inn Fields, where it is still enshrined. What it lost in municipal privileges it more than gained in academic influence, and in 1843 its title was enlarged to become the Royal College of Surgeons in England. In 1931 the foundation stone was laid of the Buckston Browne Research Farm, the gift to the College made by its Fellow, Mr. George Buckston Browne. The farm is at Downe, in the rural Kentish outskirts of London, adjoining Darwin's Home, Down House, which was presented as a memorial of Darwin to the British Association by the same munificent donor.

Early in the nineteenth century, too, the Royal College of Physicians moved from Warwick Lane to its present home in Pall Mall, its new abode designed by Sir R. Smirke, being opened in 1825. Mention must also be made of the founding in 1800 of the Cow Pock Institution, which became a couple of years later the Royal Jennerian Society and eventually the National Vaccine Institute. It was the result, of course, of the publication in 1798 of Jenner's famous *Inquiry* and the world-wide adoption of vaccination against smallpox that took place during the Napoleonic Wars.

But these were only incidental to the outstanding development during the nineteenth century of the great series of sanitary measures forced upon the country by industrialism and urbanisation. Probably the greatest single influence in bringing these about was Jeremy Bentham, born in 1748, whose multitudinous essays on social reform had created a deep impression upon many educated minds. Associated with Bentham and surviving him, were two practical men, Edwin Chadwick and Southwood Smith. Under the Poor Law Act of 1834 three Poor Law Commissioners were appointed to whom Chadwick became secretary; and their task was to supersede the old, unsatisfactory method of parochial relief by grouping parishes into unions, each under a self-elected Board of Guardians. Eventually about 600 of these administrative Unions took the place of a former 15,000 Poor Law parishes. Two years later a Registration Act covering births, deaths, and marriages began to put vital statistics upon a scientific footing; and Chadwick succeeded in obtaining an amendment that compelled the cause of death to be registered also.

Chadwick also initiated the first inquiry into the health conditions of London, and Southwood Smith, who was Physician to the Eastern Dispensary and the London Fever Hospital, which had been established in 1802, produced a startling account of the state of affairs in Bethnal Green and Whitechapel. He reported, for instance, that during the typhus epidemic of 1837, there were some streets in which every house had contained a sufferer, and not only this but in a good many cases every room of every house. Other inquiries followed, but it was an epidemic of cholera that finally precipitated legislation, and in 1848 the first Public Health Act was passed. Under this a General Board of Health was set up, of which Southwood Smith became the first medical member, one of its chief duties being to enable populous towns to establish Local Boards of Health. The authority for London became a Sewers Committee, of which Dr. John Simon was the medical officer; and he may thus be said to have been London's first Medical Officer of Health. It was a recurrence of cholera, too, that laid the foundations of what has since been called industrial medicine, when the alarmed General Post Office in 1854 established a whole-time medical service for its employees.

The General Board of Health subsequently lapsed, its duties being divided between the Privy Council and the Home Office, but it was reconstructed in 1871 under the Local Government Board Act. The Public Health Act of the following year consolidated and extended the sanitary measures and powers of local authorities all over the country, and made obligatory the appointments of local medical officers of health. And the great Public Health Act of 1875 with its provisions in respect of drains, sewers, water supplies, the inspection of food, and prevention of epidemics, completed the foundations of our present sanitary code. A Local Government Act of 1884 established Urban and Rural District Councils, and another of 1888, in which County Councils were empowered to appoint medical officers of health, forbade the appointment of such officers to any area containing more than

50,000 persons unless they held a Diploma of Public Health. In 1889 and 1895 acts were passed strengthening the compulsory notification of infectious diseases and the provision of suitable isolation hospitals; and since then further whole-time medical services have been created to deal with the inspection of school children, the treatment of venereal diseases, and pulmonary tuberculosis. In 1919 the Local Government Board expired and the Ministry of Health assumed its functions, thus bringing about a further co-ordination of the country's preventive and sanitary services that is still in process of completion.

Side by side with all this legislation London witnessed a great extension of its hospital facilities, and especially of those dedicated to the treatment of particular diseases. Thus, in 1802 the Royal London Ophthalmic Hospital was founded in Charterhouse Square, removing to Moorfields in 1821 and the City Road in 1899. In 1814 and 1816 the Royal Chest Hospital in the City Road, the Royal Waterloo Hospital for Women and Children, and the Royal Westminster Ophthalmic Hospital were established. In 1852 the Great Ormond Street Hospital for Children was founded, and during the following twelve years the Poplar Hospital for Accidents, the Western Ophthalmic Hospital in Marylebone Road, the National Hospital for Diseases of the Heart, the Royal Dental Hospital, the Queen's Square Hospital for Nervous Diseases, St. Peter's Hospital for Stone, the National Dental Hospital, and the Golden Square Hospital for Diseases of the Ear, Nose, and Throat, all made their appearance.

The number of the great general hospitals had also been increased. Charing Cross was founded in 1818. The Royal Free Hospital was established near Hatton Garden in 1828 and removed to Gray's Inn Road in 1842. It took its title from the fact that—contrary to the practice at most of the other hospitals—it did not demand a letter of recommendation with its pauper patients; and it was at the Royal Free, in 1877, that the medical staff was first authorised to give clinical instruction to members of the London Medical School for Women. University College Hospital was opened in 1834 with 130 beds, and it was here on December 21, 1846, with the nineteen-year-old Lister looking on, that the first major operation under an anæsthetic was performed in this country.

In 1839 King's College Hospital was established in Portugal Street, Lincoln's Inn—to be removed in 1913 to Denmark Hill—and it was this hospital that had the honour, in 1877, of persuading Lister to leave Edinburgh and preach his gospel of antiseptic surgery in London. Probably, from the scientific standpoint, this was the most important date in London's medical calendar during the nineteenth century. For though the new epoch had been tentatively ushered in by one or two of his former pupils—notably Howse at Guy's and Marcus Beck at University College Hospital—it was not until Lister himself took up the gauntlet that the London surgeons became converted.

By then St. Mary's Hospital had been created to serve the poor in the Paddington district, and St. Thomas's had been removed to the Lambeth

Embankment to make room for the London Bridge railway station. In its new form of a series of pavilions it exemplified the fresh ideas creeping into hospital structure; and it was at St. Thomas's Hospital that there had been founded in 1860 the Nightingale School and Home for Nurses—named after the great woman chiefly responsible for the science of modern nursing. Between 1870 and 1880 there was also an intensive construction of Poor Law infirmaries, and those at Bermondsey, Camberwell, Chelsea, Greenwich, Holborn, Lambeth, Shoreditch, Kensington, Woolwich, Whitechapel, and St. George's-in-the-East, were all built during this decade.

Meanwhile, in London, as elsewhere, the whole character of medical teaching had been systematised and transformed as indicated in an earlier section (Chap. IV, p. 182). The founding of London University in 1828—transformed into University College in 1836 when the University of London received its Charter and Chancellor—had provided a much-needed opportunity. It enabled poor students to obtain an education of the university type, and it was free from the ecclesiastical restrictions of the older English universities. It was for this reason that the Quaker Lister became one of its students, and with its associated hospital it ushered in a new era in London medical education. Under later reconstitutions the University of London has greatly extended its borders; and the medical schools then or subsequently attached to all the principal London hospitals have since become Schools of the University in the Faculty of Medicine.

Concurrently with this advance in educational standards it was felt that some check was required upon private practice; and in 1858, thanks very largely to the efforts of Dr. John Simon—who had then become medical officer to the Privy Council—a Medical Act was passed to regulate the qualifications of practitioners in medicine and surgery. A General Council of Medical Education and Registration of the United Kingdom was created, and the first Medical Register was published in 1859.

The Council was further authorised to prepare and sell a new pharmacopæia, which appeared in 1864 as the now well-known *British Pharmacopæia;* and the Royal Colleges of Surgeons and Physicians established a Conjoint Board of Examiners for such students as were not taking a university degree in medicine or contenting themselves with the licentiateship of the Society of Apothecaries.

Such in brief has been the development of medicine in London and London's influence on the development of medicine in general. But a word must be said in respect of a characteristic feature of London medical life. It was out of an informal group of London physicians meeting to discuss their problems in Linacre's house, that the Royal College of Physicians emerged as an official body, and the medical society in sundry forms has existed ever since. These have been too numerous to mention in detail, and the majority of existing societies were ultimately united under the banner of the Royal Society of Medicine.

This is now spaciously housed in Wimpole Street, but in its more modest beginnings, as the Medical and Chirurgical Society, it met in Verulam Buildings, Gray's Inn. It was founded in 1805, and amongst its earliest sponsors were Matthew Baillie, the nephew of John and William Hunter, Jenner, Abernethy, Cline, and Astley Cooper. In 1834 it had become sufficiently important to receive a Charter from William IV and add the word Royal to its title. In 1907, thanks very largely to the efforts of its secretary, Sir John MacAlister, it received a supplemental Charter, and under the title of the Royal Society of Medicine absorbed seventeen smaller societies.

A few have continued, however, to remain independent, and of these the oldest is the Medical Society of London, dating from 1773. It first met in the house of Lettsom, a Quaker physician, who had been the pupil at St. Thomas's of the poet Mark Akenside, and had afterwards become one of the ablest as well as one of the most generous of London's physicians. He was the prime mover in the establishment of the Royal Sea Bathing Infirmary at Margate, and incidentally one of the introducers into England of the mangold wurzel.

Of the other independent societies, perhaps the most considerable are the Hunterian and the Harveian. The Hunterian Society was founded in 1805 as a means of association for East End practitioners, and amongst its first patrons was Sir William Blizard, the last of the old coffee-house consultants and the founder of the London Hospital Medical School. The Harveian, which began in 1831, was intended to do for practitioners in West London what the Hunterian did for those in the

East; and although neither has a building, both have worthily sustained an old and great tradition.

The Anatomical Society of Great Britain and Ireland was founded as the result of an informal meeting of Anatomists, which followed a letter dated April 27, 1887, signed by the late Mr. C. B. Lockwood and circulated among British Anatomists, stating that such a meeting would be held on Friday, May 6, 1887, at the rooms of the Medical Society of London, at which Professor G. M. Humphrey of Cambridge had kindly consented to take the chair.

Finally, a word must be said in respect of the organisation of research, which has led to the formation, under a charter of 1920, of the Medical Research Council. This, as indicated in Chapter V, has developed from a committee appointed in 1913 to administer funds provided under the National Health Insurance Act of 1911. It is responsible to a committee of the Privy Council, which consists of those ministers who are in charge of the principal Government departments concerned with matters of public health both at home and overseas. From Parliament it receives a substantial annual grant of money, and it has also been entrusted, from time to time, with grants from various public bodies as well as private benefactors for general and particular researches.

About a third of its income is appropriated to the National Institute for Medical Research at Hampstead, the remaining two-thirds being spent in aid of various researches undertaken in other institutions throughout the country. At the National Institute the work is organised into several main departments, concerned with experimental pathology and bacteriology, applied optics and microphotography, biochemistry, pharmacology, applied physiology, and hygiene; and there is an auxiliary research farm a few miles away at Mill Hill.

This may be said to be the centre of the Medical Research Council's activities. But it is also responsible for certain travelling fellowships. It has established sub-committees, drawn at large from medical and scientific workers all over the country, for the study of such particular problems as nutrition, mental disorders, tuberculosis, radiology, anæsthetics, school epidemics, and many others; and the Council has appointed an Industrial Health Research Board for the study of working conditions in factories, occupational diseases and the health of employees. The Medical Research Council, is thus in close and intimate touch with every branch of practical medicine. It maintains relations, not only with the Ministry of Health and other Government departments, but with such older and independent centres of research as the Lister Institute of Preventive Medicine, the research laboratories of many of the larger hospitals, both in London and the provinces, and the medical faculties of the various universities.

CHAPTER IX

THE MUSEUMS OF LONDON

By F. A. BATHER, D.Sc., F.R.S.

BOTH terms of this chapter heading are ill-defined, and any attempt to set a rigid limit might exclude institutions that it seems useful to mention and include others of but little interest in the present connection. A preliminary survey yielded about eighty permanent collections accessible to qualified persons. Doubtless there are more. We may at once eliminate such collections of pure art as the National Galleries, Kenwood, the Wallace Collection, and the picture galleries of Dulwich College and the Guildhall. The National Portrait Gallery in St. Martin's Place, W.C., must be mentioned if only for its portraits of Arctic explorers; and Sir John Soane's Museum (13 Lincoln's Inn Fields) to promote 'the study of architecture and the allied arts,' is too interesting to be omitted, apart from its sarcophagus of Seti I and other Egyptian, Greek, and Roman antiquities.

From the seventy or more extant museums that remain we may discard others that enshrine the memory of individuals, for scientific interests cannot be associated with the Robert Browning Museum (197 Walworth Road, S.E.17), Carlyle's House (24 Cheyne Row, Chelsea), Dickens' House (48 Doughty Street, W.C.1), Dr. Johnson's House (Gough Square, E.C.4), Keats' House (Wentworth

Place, Hampstead, N.W.3), or Wesley's House (47 City Road, E.C.1).

Even after these excisions our list retains over three score museums of more or less scientific content, and a practical classification for them is not easy to find. We may say that some sixteen are national, *i.e.*, supported by the State. Museums of fairly wide scope, maintained by public bodies, number five. Then there are thirteen smaller museums administered by municipalities and generally specialising in the history, the crafts, and the natural history of the locality, but sometimes with exotic collections of unexpected interest. Finally come about thirty-two special museums, some of the highest scientific importance, mostly maintained by semi-public bodies or established societies, but a few by private funds. This classification cuts across the subject-matter of the museums, but it will serve our purpose, for any classification by content would involve constant repetition.

So far only existing museums have been considered; but London has had many other museums now dispersed or absorbed, yet in their day of considerable importance. It is well to begin with an account of them, partly to illustrate the origin of those that survive, partly to indicate some sources of surviving material.

The library and museum of antiquities formed by Sir Robert Cotton (1570-1631) were already known at home and abroad before the close of the sixteenth century; they were continually increased till near the end of his life. In 1700 his great-great-grandson, Sir John Cotton, fourth Baronet, made them over to the nation, which vested them in trustees (12 & 13 William III, Cap. 7). In 1707 there was already a project, for uniting them with the collections of Henry, Prince of Wales, and Lord Arundel as the foundation of a national museum.

With Cottonian coins and Arundel marbles this chapter has little concern. More germane to its purpose is the 'MUSÆUM TRADESCANTIANUM, or a collection of Rarities preserved at *South-Lambeth*, neer *London*, by John Tradescant,' familiarly known as Tradescant's Ark. Begun by John Tradescant, gardener to Charles I, in 1625, it was continued by his son and successor, who in 1656 published the catalogue just quoted and in 1659 conveyed it to Elias Ashmole, the antiquary. Ashmole transferred it, with his own collection, to Oxford University in 1682, and it was lost to London.

About the same time Robert Hubert (also written Hubbard) *alias* Forges made a collection 'of many natural rarities,' which he exhibited at Leipzig and Hamburg during the Commonwealth, and in 1664 'at the Miter, near the west end of St. Paul's Church.' Part of this collection came, through Courten, into the hands of Sloane, but the bulk was bought for the Royal Society by Daniel Colwal or Colwall, one of its officers. Thus the ultimate resting place of both parts was the British Museum.

William Courten or Charlton (1642-1702), of the Middle Temple, made, says Evelyn (*Diary*, 16 December, 1686, also 11 March, 1690) 'such a collection as I had never seen in all my travels abroad .... gather'd by himselfe travelling over most parts of Europe . . . . estimated at £8,000.' It was bequeathed to Sir Hans Sloane, but reached him in some confusion. Various plants and minerals in the Natural History Museum are from this source. Courten's tomb in Kensington churchyard, carved by Grinling Gibbons, bore these words:

> Gazarum per Europam indagator sedulus,
> quas hinc illinc sibi partas negavit nemini,
> sed cupientibus exposuit humanissime.

The museum of the Royal Society, initiated by Daniel Colwal in 1666 with the above-mentioned purchase, was housed at Gresham College and soon attained sufficient importance to demand cataloguing. The task was entrusted in 1678 to the plant anatomist and physiologist, Nehemiah Grew, who published his description in 1681. A hundred years later this collection of 'natural and artificial rarities' was presented to the British Museum, where may still be seen the frontlet of the West African Dwarf Buffalo and a Mastodon tooth described by Grew, a Steneosaurus described by Chapman in 1758, and a Plesiosaur described by Stukeley in 1719 (*cf.* Chap. II).

Next, in both time and importance, is the museum of James Petiver (1663-1718), apothecary to the Charterhouse, who corresponded with naturalists all over the world and described his specimens in a series of publications. On his death all were purchased by Sloane and some are preserved among the minerals, in the herbarium, and in two folio volumes of flattened insects.

The museum of Dr. J[illegible]n Woodward (1665-1728), though mentioned alongside that of Sloane in a line of Pope's, need not detain us, for he bequeathed his English fossils to Cambridge, while his foreign fossils were dispersed by sale, as also were his Roman antiquities.

Dr. Richard Mead (1673-1754) spent the wealth acquired as a physician in forming a museum at his house in Great Ormond Street, and it 'became a repository of all that was curious in nature or in art.' His most famous specimen was a mummy (one of the three then in England); it was bought at his sale by Dr. William Hunter, and is presumably that now in the museum of Glasgow University.

John Conyers, an apothecary of Shoe Lane and a contributor to the *Philosophical Transactions*, proposed to open his museum of rarities to the public in 1691, but it seems to have been sold two years later, and Sloane probably got some of it.

Dru Drury (1725-1803), a silversmith in the Strand, formed a fine collection of insects, many of which he described in his *Illustrations of Natural History* (1770-73-82). Some of the type specimens came to the British Museum in 1839 by way of the G. Milne collection.

Probably the most famous in its day of the London museums was the Museum Leverianum of Sir John Ashton Lever (1729-1788). Having formed it at Alkrington Hall, near Manchester, he removed it to London in 1774 and opened it for public exhibition in Leicester House, charging an admission fee of half-a-guinea at first. The receipts, though large, did not balance the lavish expenditure, and Sir Ashton decided to sell. The collections, valued before a parliamentary committee at £53,000, were offered to the British Museum in 1783 at a reduced price, but were declined by the trustees. Sir Ashton in 1784 obtained an Act of Parliament permitting him to dispose of the museum by lottery, and in January, 1788, he died. The prize was won by James Parkinson, a dentist, who removed it to the Rotunda, near the Surrey end of Blackfriars Bridge. Here it was popular for some years, but was brought to the hammer in May, 1806. The museum contained specimens valuable in themselves and often of scientific importance, thanks to descriptions by George Shaw, Latham, and others. Most notable were the articles collected by Captain Cook on his last voyage. The British Museum still held aloof, and the Cook relics fell mostly to the representatives of the Emperor Francis I of Austria and Lord Stanley, afterwards 13th Earl of Derby; they are now in the museums of Vienna and Liverpool. Other purchasers were Sir John Soane, Bullock, and the naturalists, Pennant, Atkinson, Macleay, Swainson, Latham, and Edward Donovan. This last (1768-1837) drew up the catalogue, purchased 500 lots, and started the London Museum and Institute of Natural History in Catherine Street (Strand). His collection was eventually sold, and this time the British Museum was among the purchasers, obtaining at least one bird that had been in the Leverian Museum (G. R. Gray, *Catal. Brit. Birds*, 1863).

Of William Bullock, most remarkable among early popularisers of museums, neither the date nor place of birth or death is known. About 1795 he began to form his collection in Sheffield, and there in 1799 was published the first edition of *A Companion to Bullock's Museum, containing .... upwards of Three Hundred Curiosities.* 'Addenda' were printed at Coventry, but in 1801 the museum was removed to Liverpool where Bullock set up as silversmith. In 1809 he moved his collection, now of over 4,000 curiosities, to London, where it was housed at 22 Piccadilly. It continued to grow while an Egyptian Temple (later the Egyptian Hall) was built to receive it in 1812, under the name of the London Museum and Pantherion. In 1819 Bullock sold his collection of more than 32,000 objects, but retained the hall as a showroom and saleroom till 1825. At the sale the chief museums of this country and the continent were represented, W. E. Leach being the buyer for the British Museum. Bowdler Sharpe in 1906 (*Hist. Collections in N.H. Depts. of B.M.*, Vol. II) gave extracts from the sale catalogue, noting specimens purchased by Leach, few of which had survived to his day. Leach paid no attention to the Cook specimens, of which Berlin this time secured a large share.

On many other museums that attracted the fashionable public of the eighteenth century we need waste no time, for they were little more than Barnum shows. Don Saltero's Coffee House in Cheyne Row, Chelsea, founded by a servant of Sir Hans Sloane, is described by Steele in *The Tatler* (No. 34). The museum of James Cox in Spring Gardens appears in Fanny Burney's *Evelina* (Letter XIX) and is referred to in *The Rivals*.

We complete our list of vanished museums with three of an entirely different class; those established by great corporations for purely scientific purposes and largely to preserve specimens collected or described by their members. The Geological Society of London, founded in 1807, began its museum on January 1, 1808, with a cabinet presented by Dr. William Babington, which soon received specimens from Sir Joseph Banks, G. B. Greenough, and others; these included 'a collection of rock specimens formed under Werner at Freyberg.' Where this cabinet was kept is not clear, but in 1810 there were several cabinets and the society took rooms at 3 Lincoln's Inn Fields. Leonard Horner from then till his death in 1864 devoted much time to the arrangement of the collections, but in 1812 Thomas Webster was appointed Keeper of the Museum. When, in 1828, the society was provided with apartments in Somerset House, the greater part of the space was occupied by the museum, which served both education and research. William Lonsdale was then librarian and curator. He was assisted for a time by Searles V. Wood, then by S. P. Woodward, and in 1842 he was succeeded by Edward Forbes, who, as well as Woodward, retired in 1845. During the 'sixties the growth of the library restricted that of the museum, and when the society moved to Burlington House in 1874, numerous duplicates were presented to the British Museum, the Museum of Practical Geology, and other institutions. From 1891 to 1899 Mr. C. Davies Sherborn labelled and registered the 2,000 type and figured specimens, and in 1902 a catalogue, based by J. F. Blake on Sherborn's work, was published. During this period the transference of the collections elsewhere was seriously discussed, but it was not till 1911 that the British specimens were handed over to the Museum of Practical Geology and the foreign and colonial specimens to the British Museum. Only some thirty-five show-specimens were retained.

The museum of the Zoological Society ran a parallel course in a far shorter time. Founded in 1826, with rooms at 33 Bruton Street, the society received in 1827 the Sumatran collection of its deceased president, Sir Stamford Raffles, and the collection of its secretary, N. A. Vigors (who had bought at Bullock's sale). The collections grew rapidly and were much visited. John Gould was appointed curator and preserver; he was succeeded by G. R. Waterhouse in 1836. In 1835 the museum and offices were removed to the former residence of John Hunter, in Leicester Square; but visitors declined, the premises were dangerous, and the collections were stored pending the erection of a suitable building. This, however, was beyond the means of the society, which in 1843 re-opened its museum in the old Carnivora House at the Gardens. In 1848 it presented duplicates to a number of provincial museums, and in view of the progress made in them and in the national collection, it gradually restricted its own museum activities. Finally, from 1853 to 1855, the type specimens were presented to the British Museum, which was then permitted to purchase such other specimens as it needed for £500. The rest were sold to the colleges of Galway and Cork and to several other museums. In the *History of the Collections in the Natural*

History Departments of the British Museum this is described as 'the most important historical accession ever received.' The nation 'thus regained the typical examples described from the voyage of the *Beagle* and other exploring vessels.'

The Museum of the Hon. East India Company, kept at first in its house in Leadenhall Street, received collections of Sir Stamford Raffles, Dr. Horsfield, Col. Sykes, and other famous naturalists. From 1841 onwards the directors presented of their superabundance to the British Museum. In 1858 the powers of the Company were taken over by the Crown and its museum removed to Fife House in Whitehall, as the India Museum. From then till the final dispersal of the museum in 1880, specimens from it were presented to the British Museum by the Secretary of State for India.

So much for the vanished museums of London. Among these, it may have been noted, the Sloane Museum, though often mentioned, has not been included. That is because, whatever may since have happened to the specimens it did not so much vanish as change its name. Essentially it became the British Museum, for in 1753, being the twenty-sixth year of George II, was passed 'An Act for the Purchase of the Museum, or Collection of Sir Hans Sloane, and of the Harleian Collection of Manuscripts; and for providing One General Repository for the better Reception and more convenient Use of the said Collections, and of the Cottonian Library, and of the Additions thereto.' Here we are not concerned with the books or the MSS., but almost all the other departments of the museum had their beginnings in the Sloane Collection. The story is familiar, but the chief facts must be recalled.

Hans Sloane (1660-1753), of Scottish descent but born in Ireland, studied chemistry in London, botany in the Chelsea Physic Garden, medicine in Paris, and took the degree of M.D. at the University of Orange. In 1687 he went to the West Indies with the Governor, the second Duke of Albemarle, and there began his collections in natural history. On the death of the Duke in 1689, Sloane returned to England and in his leisure worked at his *Natural History of Jamaica*, of which the first volume, published in 1708, added to his already considerable scientific reputation. He became Secretary to the Royal Society in 1693 and succeeded Newton as president in 1727. Meanwhile, he had acquired the Courten collection in 1702, the herbaria of Dr. Leonard Plunkenet in 1710, Petiver's collection in 1718, and others of less note. All these were housed in his residence in Great Russell Street, Bloomsbury; but in 1714 he had bought the Manor House of Chelsea, and thither in 1741 he transferred his museum and library. To describe their contents here is impossible. Suffice it to say that he left on his death 35,000 objects of art and antiquity, and at least as many specimens from the various branches of natural history, besides miscellaneous objects. He had wished the collections to be kept entire in the Manor House, but (unlike some moderns) he left his executors a free hand in this, directing only that they should be offered to the nation for £20,000, 'it not being, as I apprehend or believe, a fourth of their real and intrinsic value.' Parliament, as we have seen, accepted the offer, but not without difficulty due to want of money. This was overcome by a lottery. It is sometimes said that the appointment of the Archbishop of Canterbury, the Lord Chancellor, and the Speaker of the House of Commons as the three Principal Trustees, was to induce confidence in the lottery; really it was following a suggestion of Sloane's. Anyhow fraud was not prevented. The ensuing scandal 'impressed itself,' as Edwards (1870) writes, 'on the subsequent history of the institution. The Museum had been founded grudgingly. It was kept up parsimoniously.' This fact it was that led to the formation of other museums, until, after many decades, greater public appreciation furnished the trustees and the officers with more adequate means for fulfilling their duty.

Considering that Chelsea was too remote for 'studious and curious persons,' the trustees sought a home elsewhere and eventually purchased Montague House, adjoining Great Russell Street. Here, after reconstruction and arrangement, the British Museum was opened to the public on 15 January, 1759, under Gowin Knight as principal librarian, with Matthew Maty, Charles Morton, and James Empson as keepers of departments. Empson, who had been keeper of the Sloane Museum, was in charge of natural history. The barest summary of the history of the British Museum would occupy all our space; only a few leading facts can be selected.

First, as to the buildings. Numerous accessions, notably the Royal Library, the collections of Sir William Hamilton, and the Egyptian antiquities taken at the capitulation of Alexandria, led the trustees in 1804 to apply to Parliament for enlargement of Montague House. Actually that was destroyed and replaced by the bulk of the present building, designed by Robert Smirke, begun in 1823, and finished in 1852. The inner quadrangle was in 1854-7 filled by Panizzi's reading room and book corridors. The Towneley marbles (1805), the Elgin marbles (1816), and treasures from excavations in Asia Minor necessitated successive additions on the west, never enough to cope with the congestion. Almost from the outset there were proposals for removing part of the collections, and about 1860 these received serious consideration. The choice then lay between purchase of land for future expansion adjoining the museum and keeping all departments in Bloomsbury, or transferring the natural history departments to a new building on the estate of the Commissioners of the 1851 Exhibition. The former plan was advocated by Murchison and other men of science, but the latter, after years of discussion, was adopted. Plans by Alfred Waterhouse for the Natural History Museum, were finally approved in 1871; work was begun in 1873 and completed in 1880, when the removal began. The departments of geology, mineralogy, and botany were opened in April, 1881, but that of zoology was not complete till 1886. In 1897 was added a temporary whale-room, which now gives place to a permanent building; the new Spirit Building was partly finished in 1924; an extension opened in December, 1930, temporarily houses part of the entomological collections. Meanwhile, at Bloomsbury the Mausoleum Room and the south-east wing were added, and in

1894 the Government at last bought the land between the museum and the roads to west, north, and east, and on the north King Edward VII's Galleries were built in 1906-14.

Some additions to the collections have been mentioned; others during the first century are the Brander fossils from Barton, described by Solander (1766); the Cracherode collection, including fossils and minerals (1799); the Greville minerals (1810); the William Smith fossils, and the Montagu zoological collection (1816); the William Burchell mammals (1817); the library, herbarium, and museum of Sir Joseph Banks, left by him in 1820 to Robert Brown, who transferred it in 1827; the fossil reptiles of Thomas Hawkins (1834-40); General Hardwicke's birds and fishes (1835); the Mantell fossils (1839, 1853); Cautley's Siwalik fossils (1840); Brian Hodgson's mammals and birds from Nepal and Sikhim (1843-59); J. F. Stephens' British insects (1853); mammals and birds from Van Lidth de Jeude's museum, including Linnean types from Seba's collection (1858); Allan-Greg minerals (1860); Häberlein Solenhofen fossils, including Archæopteryx (1862-3); Banks' insects, including Fabrician types, from the Linnean Society, also J. C. Bowring's Coleoptera (1863); H. B. Tristram, zoology of Palestine (1864); H. Christy's prehistoric and ethnographic museum (1865); Hugh Cuming, conchological collection (1866). To continue this selection after the removal of the natural history collections to South Kensington would be too invidious a task.

Some idea of the growth of the museum may be formed from the history of its departments. At first these were but three: Printed Books, Manuscripts, and Natural History. The last, however, included all the museum objects, and it was not till 1807 that it was split into 'Natural History & Modern Curiosities' and 'Antiquities & Coins.' The latter was divided, in 1861, into the three departments; Oriental Antiquities, Greek & Roman Antiquities, and Coins & Medals. In 1866 the British & Mediæval Antiquities with Ethnography were detached from the Oriental Antiquities; but in 1921 there was a re-grouping into British & Mediæval Antiquities (with Prehistoric Antiquities) and Ceramics & Ethnography (with Oriental Antiquities). The Department of Prints & Drawings was established in 1836. Maps, topographical drawings, etc., were a separate department from 1867 to 1880, but were then placed under Printed Books. The Oriental MSS. were separated in 1867, and the Oriental Printed Books subsequently joined to them. Within the Natural History Department a botanical branch arose in 1835, followed in 1837 by branches of zoology and geology. When Owen was made superintendent of Natural History in 1856, these branches became departments, and in 1857 geology severed from mineralogy and became essentially palæontology; not till 1913 was entomology accorded departmental status. On the removal of the Natural History departments to South Kensington, Owen's successor, Flower, became director, but that officer has only just been freed from the control of the principal librarian.

The growth of a museum depends largely on the extent to which it utilises its collections. Official publication of serious work seems to have begun, with other reforms, under Planta, principal librarian from 1799 to 1827, but it did not extend to the natural history departments till J. E. Gray was made keeper of zoology in 1840. Starting with his *List of the . . . . Mammalia* in 1843, a continual flow of lists and catalogues has sought to make the riches of those departments known throughout the world. Of these the most famous is the *Catalogue of Birds* in twenty-seven 8vo volumes (1874-98).

Though qualified students have always been well provided for, other visitors had at first to apply for tickets limited in number, and were shepherded round by a member of the staff. A traffic in tickets arose and was not countered by regulation till 1805. Tickets were abolished in 1808. It does not appear that uncontrolled admission to the public galleries has been harmful; the most serious damage being the breaking of the Portland Vase by a madman in 1845. It is noteworthy that at Bloomsbury in 1860 visitors to the natural history galleries exceeded those to the antiquities in the proportion of four to three. During the past decade the visitors to the Natural History Museum have been only half as numerous as those to Bloomsbury.

At first, for printed aids the public had to rely on extraneous, even foreign publications. The first official *Synopsis of the Contents* coincided with the abolition of tickets. The publication of *Guides* began in 1859, and has continued with increasing specialisation. A guide-lecturer was appointed first in 1911 at Bloomsbury. There is now at least one such guide in all the larger national museums and in many provincial museums.

In the use of adequate labels and of attractive modes of installation to explain its exhibits to a wider public, it must be admitted that the Natural History Museum was a worthy pioneer, though other museums have since bettered its example. Here, as in other fields, the British Museum has suffered from its priority, which, with the inertia due to its bulk, prevented it from profiting by the experience and following the example of others. If it has too often created its own difficulties, this has been due less to lack of foresight in its officers and trustees than to obstacles raised by parliamentary government.

In some respects the British Museum appears to be overlapped by the Victoria & Albert Museum. Their aims, however, are entirely different. The former assembles objects in relation to civilisations past and present, keeping great series together for comparative study; the latter illustrates the different forms of art as governed by material, and obtains objects for retention or loan, to assist the craftsman and the manufacturer. The Museum of Ornamental Art, established at Marlborough House in 1852, was the offspring of the International Exhibition of 1851, engendered by the Royal Society of Arts under the presidency of the Prince Consort. The foreseeing purchase of estates in South Kensington by the Commissioners of the Exhibition with their surplus, provided a site on which the iron buildings known as 'the Brompton boilers' were erected for the museum in 1857. More permanent buildings were added between 1860 and 1884. The foundation stone of the present main building was laid in 1899 by Queen Victoria, who commanded the change of name to Victoria & Albert Museum. The new building was opened by King Edward VII in 1909.

The Indian Section of the museum departs from the general plan. Its collections, which illustrate the arts and crafts of India, Ceylon, Afghanistan, Tibet, Burma, Siam, and Indonesia, and are now in a separate building in Imperial Institute Road, originated in the East India Company's Museum, whose contents, with additions, were transferred from the India Office in 1880 (*cf.* Chap. III, Royal Asiatic Society, p. 84).

Through its Circulation Department the Victoria and Albert Museum, which is governed by the Board of Education, is in touch with the provincial museums. Its activities in this direction are confined to art, but grants are made to these museums for the purchase of various objects including specimens of natural history, and it is probable that such also may be added to the circulating series.

In 1865 some of the temporary buildings at South Kensington were offered to North, South, and East London, with the view of establishing branch museums for the help of artificers and general education. East London alone accepted the offer and purchased a site in Cambridge Road, adjoining the old Bethnal Green. Besides industrial and fine art, this museum attends to local topography and nature study, and is at present London's nearest approach to a children's museum.

The conceptions of the Prince Consort and the

Commissioners embraced science as well as art, in relation to both education and industry. The collections at Marlborough House and South Kensington, originally under the Department of Science and Art, included animal and vegetable products in their economic aspect, building materials, and a series of educational apparatus formed by the Society of Arts. With these were associated the Patent Museum, in charge of the Commissioners of Patents. In 1864 a collection of naval models and marine engines, mainly lent by the Admiralty, was added. In 1873 the Admiralty models were transferred to Greenwich, but the collection continued to grow. The Food Collection was transferred to Bethnal Green in 1872. In 1876 a Loan Exhibition of Scientific Instruments, suggested by the Royal Commission on Scientific Instruction, was held at South Kensington, and many objects from it were added to the science collections. These were increased by the transference of the Patent Museum in 1883; on the other hand limits of space necessitated the dispersal of the educational apparatus in 1888. During these years the science collections were in buildings on the west side of Exhibition Road originally constructed for the Exhibition of 1862; on the opening of the Victoria & Albert they assumed the title of the Science Museum. A worthy building became a necessity, and plans were drawn up by a departmental committee appointed by the Board of Education in 1911, for a museum consisting of eastern, central, and western blocks. Of these the fine eastern block was opened by King George V in March, 1928. The main divisions are

I—Industrial Engineering; II—Stationary Engines, Land Transport, Building Construction; III—Water and Air Transport; IV—Science and Scientific Apparatus. The term 'Science' covers astronomy and physics. It is a sign of the times no less than of its admirable organisation, that this museum now rivals the old British Museum in popularity, and the number of visitors will doubtless increase with the opening of the Children's Gallery.

Between the Science Museum and the Natural History Museum is now rising a building for the Museum of Practical Geology, which since 1851 has occupied the building erected for it between Jermyn Street and Piccadilly. It was established on the suggestion of Sir Henry De la Beche, founder of the Geological Survey of the United Kingdom, to preserve the specimens collected by the Survey, and for this purpose, in 1837, apartments were allotted at 6 Craig's Court, Charing Cross. As the Museum of Economic Geology it was opened to the public in 1841, under the control of the Office of Woods & Forests. In 1853 both survey and museum were transferred to the newly created Department of Science & Art, merged in the Board of Education in 1900; and from this it was removed in 1919 to the Privy Council's Committee for Scientific & Industrial Research. Thus there will be, adjoining and physically connected at South Kensington, three museums of science, each administered by a different body. This should give the newly appointed Standing Commission on Museums an opportunity of proving its value.

The collections of rocks, minerals, and fossils are essentially British, and practical aims govern their arrangement. Thus economic geology bulks largely, the minerals are arranged topographically and according to their economic uses, and the primary order of the fossils is stratigraphical, not, as in the British Museum, biological. The occurrence of foreign and colonial specimens among the ores recalls a former connection with the Royal School of Mines.

An easy transition takes us to the Imperial Institute, opened in 1893 by Queen Victoria as a national memorial of her jubilee. Its principal object is to promote the utilisation of the commercial and industrial resources of the Empire, by the investigation of raw materials, the supply of relevant information, and the maintenance of comprehensive exhibits illustrating the economic resources of all the countries of the Empire overseas. The galleries excellently perform the educational functions of a museum for the public of all ages. The Institute was placed under the Board of Trade in 1902, and was transferred to the Colonial Office informally in 1907, and formally by Act of Parliament in 1916. Another Act, in 1925, provided for its management under the Parliamentary Secretary of the Department of Overseas Trade, by a Board of Governors representing all the interests concerned, and for the amalgamation with it of the Imperial Mineral Resources Bureau. The Institute is maintained by contributions from all the constituent parts of the Empire.

The remaining national museums need not occupy us long. Adjoining the Imperial Institute is the Imperial War Museum, opened in 1920 to preserve relics of the Great War and to illustrate its every phase. Its collections are soon to be moved to the old Bethlem Hospital, Lambeth.

Of collections connected with war, the oldest are The Armouries, begun at Greenwich by Henry VIII and removed to The Tower by Elizabeth. Placed under the Trustees of the British Museum in 1903 they were transferred to H.M. Office of Works in 1904, and now have the same curator as the War Museum. Next comes the Royal Naval Museum in the College at Greenwich. It contains the contents of the museum attached to the Navy Office in Somerset House till 1832, and subsequently, as noted above, sent to South Kensington till 1873; also gifts to the Royal Naval Hospital while in Greenwich (1710-1860), and many subsequent donations. It will be absorbed in the National Maritime Museum when the Queen's House at Greenwich is ready for its reception. The Artillery Museum, in the Rotunda on Woolwich Common, was opened in 1819.

The Home Office Industrial Museum, Horseferry Road, Westminster, opened in 1927, is a permanent exhibition of methods and appliances for promoting the safety, health, and welfare of industrial workers.

The Museum of the Public Record Office in Chancery Lane was opened in 1902. It contains historical documents and objects connected with their preservation. The museum at the General Post Office, King Edward Street, E.C.1, is for the use of the staff.

The Museums of Economic Botany in the Royal

Botanic Gardens at Kew, opened in 1910, have been briefly described in Chap. VI.

The recently begun National Collection of Type-cultures of Bacteria is at the Lister Institute, Chelsea Gardens, S.W.1.

Finally, The London Museum *par excellence*, first established in Kensington Palace through the efforts of the late Viscount Esher and the late Viscount Harcourt, was transferred in 1913 to Lancaster House (formerly Stafford House), St. James's, then presented by Viscount Leverhulme to the nation. The specimens illustrating the earlier history of London may be regarded as within our scope.

Turning to the larger non-national museums we find the history of the city dealt with in the Guildhall Museum, opened in 1876. Besides antiquities, a collection of old time-pieces deserves mention. It may be noted here that the City of London maintains Queen Elizabeth's Lodge in Epping Forest, where are the collections of the Essex Field Club.

The chief museum maintained by the London County Council is the Horniman Museum at Forest Hill. The miscellaneous collections of Frederick John Horniman (1835-1906) shown at first in Surrey House Museum, were presented by him with the new building to the people of London and opened in 1901. The significant order governing the subsequent arrangement makes this a model among educational museums of ethnology and natural history.

Among museums connected with London University, those at University College, Gower Street, embrace important collections of Egyptology made by Edwards and Flinders Petrie, of human anatomy, of vulcanology made by Johnston-Lavis, and departmental collections in geology, zoology, and botany. At King's College, in the Strand, the department of physics contains the George III Museum of mechanical models and philosophical instruments made by that King and presented by Queen Victoria, but now mostly removed to the Science Museum. The Architectural Museum, with original drawings by Sir Gilbert Scott, is noteworthy; and there are good teaching collections in other departments. The collections of the Imperial College of Science are also admirably adapted to their purpose, but material of historic importance is generally transferred to a national museum.

Smaller municipal museums of general character are as follows:—

Battersea Central Library, Lavender Hill, opened in 1927, where Battersea enamels are a feature.

Bermondsey, at the Rotherhithe Branch Library, Lower Road, S.E.16, opened in 1905 with a collection of fossils, and being revised to illustrate the history of leather and other industries of the locality.

Camberwell, in its South London Art Gallery, opened in 1898, has London antiquities and local pottery.

Chelsea Museum in the Public Library, Manresa Road, was opened in 1899.

Edmonton Museum in the Central Library, N.9, boasts a photographic survey.

Gunnersbury Park Museum under the District Councils of Acton, Ealing, Brentford, and Chiswick, contains local antiquities.

Hampstead Museum in the Central Library, Arkwright Road, illustrates local history, archæology, and natural history; there is a small Children's Museum.

Southwark's Cuming Museum, Walworth Road (opened 1906) started with the collection formed by Richard Cuming and his son, H. Syer Cuming, to illustrate man's handwork from prehistoric times to the present; it has since acquired local antiquities and the Edward Lovett collection exemplifying folk superstitions.

Stepney has the Whitchapel Museum, High Street, E.1, with local antiquities and miscellaneous zoological and ethnological collections; also St. George's Nature Study Museum, Cable Street, E.1, devoted to living examples of the British fauna.

Tottenham Museum in Bruce Castle, Lordship Lane, N.17, the house of Sir Rowland Hill, contains postal relics, historical collections, stone implements, and products of the West Indies from the Wembley Exhibition.

West Ham Corporation, with the Essex Field Club, controls the Essex Museum of Natural History, Romford Road, Stratford, opened in 1898; the collections are of much local importance.

Woolwich & Plumstead Museum, William Street, S.E.18, opened 1919, contains besides local collections, archæological and natural history specimens of diverse provenance.

Some of the special museums of London are in the first rank; yet hardly more than a list can be given.

The Museum of the Royal College of Surgeons, Lincoln's Inn Fields, is not so special as its name suggests. The collection of John Hunter, which forms its basis, was very miscellaneous, and remained so even after the elimination of 'articles of vertu' and the transference in 1845 of stuffed vertebrates to the British Museum. Beginning in 1763, Hunter in 1784 built a gallery at the back of his house in Leicester Square. He died in 1793 and his will offered the museum to the Government, which at last, in 1799, bought it for £15,000 and entrusted it to the Corporation of Surgeons, which then became the Royal College. In 1806 it was removed to a house in Lincoln's Inn Fields, while the present building was erected and in 1813 opened. Extensions were made in 1835, 1847, and 1891. Though the collections cover almost all branches of biology, the treatment is in the main on the line of physiological and comparative anatomy.

Though it was closed in 1914 the Polytechnic Museum in Chenies Street should be mentioned here. It was founded about 1900 by Sir Jonathan Hutchinson to meet the demand for post-graduate medical study in London and contained many thousands of drawings and photographs of cases of disease, made at the charge of its founder.

The Wellcome Historical Medical Museum, 54a Wigmore Street, was founded by Dr. Henry S. Wellcome in 1913, to receive collections made by him in many parts of the world. It was reorganised, with important additions and exemplary technique, in 1926. The title must be interpreted in the very widest sense.

The Parkes Museum of the Royal Sanitary Institute, 90 Buckingham Palace Road, was founded in 1876 as a memorial to Dr. E. A. Parkes. The exhibits illustrate disinfection, food, infant care, animal diseases, and dwelling-house sanitation.

The Institute of Hygiene, 28 Portland Place, W.1, was opened in 1904. Its exhibits are connected with food, clothing, and the house. Here is the clothing worn by Scott's Antarctic Expedition.

The Pharmacognosy Museum of the Pharmaceutical Society of Great Britain, 17 Bloomsbury Square, founded in 1842, contains drugs arranged in morphological groups and subordinately under families and genera; there are a few collections of historic interest.

The students' museums of the various hospitals comprise pathology, human anatomy, and materia medica. The Gordon Museum at Guy's Hospital, St. Thomas' Street, S.E.1, the gift of Mr. Robert Gordon, opened in 1905, is the largest. There are also the museums of the London Hospital, Turner Street, E.; St. Bartholomew's Hospital, W. Smithfield, E.C.1, with some of the earliest specimens; St. George's Hospital, Hyde Park Corner, S.W.1; the Middlesex Hospital, Mortimer Street, W.1, with anatomical preparations of Sir Chas. Bell and others; St. Mary's Hospital, Paddington, W.2; and the R. Veterinary College, Great College Street, N.W.1.

A museum is attached to the Royal Army Medical College, Grosvenor Road, S.W.1. The Royal Army Medical Corps has recently established one for instruction at the Duke of York's Headquarters, Chelsea.

A Museum of Child Welfare in Carnegie House, 117 Piccadilly, W., is administered by the National

Council for Maternity and Child Welfare. The National Institute for the Blind in 1930 opened at 224 Great Portland Street, W.1, a museum of models and apparatus employed in teaching the blind, also of mechanical devices for use by the blind.

The Linnean Society, Burlington House, W., dispersed its museum in 1863, retaining only those Linnean specimens which it had purchased in 1828 on the death of Sir J. E. Smith; they consist of plants, shells, and insects.

The Royal Botanic Society's Museum in Regent's Park was opened in 1852 to illustrate educational and economic botany (Cf. Chap. III, p. 109).

The Society of Antiquaries, Burlington House, has a small collection of antiquities, pictures, prints, and the like.

The private museum of Alexander Keiller, Esq., F.S.A., at 4 Charles Street, W.1, contains important prehistoric antiquities.

The museum of the Palestine Exploration Fund at 2 Hinde Street, Manchester Square, W.1, comprises antiquities and some natural history specimens.

Bryant & May's Museum of Firemaking Appliances at Fairfield Works, Bow, originated in a collection bought from the late Edward Bidwell in 1926.

The Donaldson Museum at the Royal College of Music, Prince Consort Road, S.W.7, contains many rare instruments.

The Architectural Association, 34 Bedford Square, W.C.1, has a small museum with samples of building stone.

The Geffrye Museum was opened by the London County Council in 1914 in the old almshouses of the Ironmongers' Company (built 1715). It illustrates and assists the local industry of furniture-making; also domestic metalwork, cooking, and lighting apparatus.

Ethnographical collections obtained by their members are preserved by the London Missionary Society, 48 Broadway, Westminster; the Church Missionary Society, 6 Salisbury Square, E.C.4; and the Baptist Missionary Society, 19 Furnival Street, E.C.4. Here may be mentioned the Mocatta Museum of the Jewish Historical Society of England, at University College, Gower Street; and the Museum of the Order of St. John of Jerusalem, at the headquarters, St. John's Gate, Clerkenwell, E.C.1. A museum of relics of explorers and other objects of geographical interest is maintained by the Royal Geographical Society, Kensington Gore.

The Royal Institution, 21 Albemarle Street, W.1, had in its early days a good mineralogical collection. This was dispersed in the 'seventies, but there remains the collection of historical apparatus of Davy, Faraday, Tyndall, and others intimately associated with the Institution, as recounted in Chapter III (p. 50).

The museum of the Royal United Services Institution in Whitehall, illustrates the history and weapons of the fighting services. In 1931, its centenary year, a special exhibition of panoramic models shows the development of war-vessels from the canoe to the capital ship.

The general history of the London museums, somewhat obscured by multiplicity of detail in the preceding pages, shows progress in two main directions. One is the increased use of museum material for the advancement of science, so that a museum is now no longer a mere repository of historic documents but is also an institute of research. The other is the educational use, and this, which embraces all ages and all classes of the community, is undergoing rapid development. Among other directions the national museums are now stretching out an even more friendly hand to those of the provinces. Much has been done already as a result of the recent Royal Commission on National Museums, and more will doubtless be done by the Standing Commission which it recommended. In this work the Carnegie Trustees of the United Kingdom are co-operating with the Museums Association, and the progress is recorded in that association's monthly organ, *The Museums Journal.*

CHAPTER X

A BRIEF HISTORY OF THE LONDON MAKERS OF SCIENTIFIC INSTRUMENTS

By ROBERT S. WHIPPLE, M.I.E.E., F.INST.P.

SIR ARTHUR EDDINGTON, opening the twenty-first annual exhibition of the Physical and Optical Societies on January 6, 1931, dwelt in his address on the fact of the interdependence of the scientific worker and the scientific instrument-maker. I cannot do better than quote his words[1]:—"An exhibition like this brings home to us two things—the debt of the scientific worker to the instrument-maker, and the debt of the instrument-maker to the scientific worker. I do not know which to place first. I do not think one can be placed before the other; for the instrument-maker provides the resources of the scientific worker, and the scientific worker provides the resources of the instrument-maker.'

In this review of the part played by London in the advancement of science it may, therefore, not be unprofitable to consider the growth of the scientific instrument-making industry.

The earliest scientific instrument-maker in London of any standing was Humphrey Cole (*c.* 1570), the maker of the astrolabe used by Sir Francis Drake, an outstanding example of beautiful workmanship. The first maker of standing to advertise, as the phrase is now understood, was Elias Allen. He had, in 1611, an advertisement in *Speculum Topographicum*, a book describing his and other forms of surveying instruments; later (1632), in a book by W. O(ughtred) describing Oughtred's double horizontal dial, it is stated that it is printed for Elias Allen 'Maker of these and all other Mathematical Instruments and are to be sold at his Shop over against St. Clement's Church without Temple-barr.'

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[1] *Proc. Phys. Soc.*, March, 1931, Vol. 43, p. 120.

Allen made the first straight logarithmic slide rule about 1630 for Oughtred, the inventor. This consisted of two rules, not connected, but which were kept together by hand. A slide rule inscribed 'Made by Robert Bissaker, 1654, for T.W.' about two feet long, and with nineteen scales, is exhibited in the Science Museum at South Kensington.[1] This rule was made before that of Seth Partridge, and is clearly the forerunner of the modern slide rule. Partridge published a description of his rule in 1671: 'The Description and Use of an Instrument called the Double Scale of Proportion.' Near the beginning of the book he states: 'Here might have been expected a print of the rule, but in regard to its sliding it could not well be demonstrated; wherefore I thought it good to advertise that this scale and all other mathematical instruments are accurately made by Mr. Walter Hayes at the Cross-Daggers in More-Fields, next door to the Popes-Head-Tavern, London.'

The latter part of the seventeenth century was a period of great scientific activity, and the majority of the English workers lived in London, Oxford, and Cambridge. Practically all of them were members of the small coterie that formed the Royal Society. Several of them, like Hooke and Newton, made their own apparatus or assisted the instrument-maker to perfect his work. There is now little doubt that a microscope which has been known as 'Dr. Hooke's microscope' for many years was made by Christopher Cocks, a well-known instrument-maker who was in business in 1672. Another distinguished maker of microscopes was John Marshall, from about 1685 to 1725. In the details of construction his instruments were far in advance of any made before him.

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[1] See "Drawings of a Logarithmic Slide Rule made in the year 1654," by David Baxandall, p. 163, in *Modern Instruments and Methods of Calculation; a Handbook of the Napier Tercentenary Exhibition*, by G. Bell & Sons Ltd., London.

Benjamin Martin (1704-1782) was not only an instrument-maker of mark but also a writer of a large number of elementary science books which had a great influence in this country in popularising science and in developing the use of scientific instruments. He invented the drum type of microscope, and was one of the first to use, if he did not actually invent, the glass scale micrometer. He also introduced into the microscope the rack and pinion method of focussing.

One of the most celebrated instrument-makers of the eighteenth century was George Adams (1704-1773). He evolved many varieties of microscope, and made a wide range of instruments for use in astronomy, surveying, and the teaching of physics. He was also a prolific author, his book *Micrographia Illustrata* being for many years the standard treatise on the subject. He was succeeded by his son, George (1750-1795) who continued to develop the business, especially that side concerned with the manufacture of microscopes. His book, *Essays on the Microscope*, published in 1787, was an important contribution to the subject of microscopy. On the death of George Adams the younger, the business passed to his brother, Dudley Adams, who continued to trade at the old address until 1825. The copyright in George Adams' books was purchased by the brothers W. and S. Jones, who built up a considerable business; a large number of instruments are in existence bearing the name of this firm. Perhaps one of the best known is the magnetometer at the Kew Observatory, which gave its name to a type of instrument—the Kew magnetometer—which for many years was the model used in the majority of magnetic observatories throughout the world.

In this connection the debt that scientific instrument makers and the users of scientific instruments owe to the British Association may well be mentioned. In 1842 the Council of the British Association approached the Government with a view to obtaining the use of the Kew Observatory as a physical observatory and laboratory. The memorandum[1] stating the uses to which the observatory would be put is an interesting document redounding to the credit of the men who visualised at that date the need of a National Physical Laboratory. The following are some extracts from the memorandum. The Observatory 'will be a repository for, and place for, occasional observation and comparison of the various instruments which the recent discoveries in physical science have suggested for improving our knowledge in meteorology, etc., in order that their relative advantages and defects may be ascertained.

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[1] *The History of the Kew Observatory*, by Robt. H. Scott, F.R.S., Proc. Roy. Soc., 1885.

'A great number of very ingenious instruments have been invented on the Continent within the last twenty years, which are practically unknown in this country, but which, if properly understood, verified, and brought into use, would lead to valuable results.'

'A repository and station for trial of new instruments . . . . . etc.

'As complete a collection as can be gathered together of the measuring instruments employed in the various branches of physical science, for the purpose of obtaining accurate quantitative results.'[1]

The latter end of the eighteenth century was rich in able instrument makers. Jesse Ramsden (1735-1800), did perhaps more than any individual instrument maker of his day to assist original scientific work. His invention of the dividing engine, *c.* 1777, enabled the circles of astronomical and surveying instruments to be divided to an accuracy previously unobtainable. The two large theodolites made for the principal triangulation of Great Britain and Ireland, are, perhaps, the outstanding monuments to Ramsden. Several sights were taken with them during the survey at distances exceeding one hundred miles. The horizontal circles are three feet in diameter, and are read to one second of arc by three micrometer microscopes of a type which Ramsden had developed, and which continues to bear his name. The triangulation measurements linked up with surprising accuracy.[1] Many instruments are in existence which bear testimony to Ramsden's conscientious workmanship and ingenuity. It is stated that before 1789 Ramsden had constructed nearly a thousand sextants from Hadley's design. The discovery of the achromatic object glass by Chester Moor Hall and its development by John Dollond (1706-61) was a great step in the development of optical instruments, as the colour-corrected lenses allowed of shorter and more easily handled telescopes. Two of the most distinguished instrument-makers of this period were John Bird (1709-1776) and Jonathan Sisson (*d.* 1747). Bird specialised in the manufacture of large quadrants and observatory instruments, and took immense care over their manufacture. His instruments are found in many of the observatories of the world; the eight-foot quadrant constructed for the Royal Observatory, Greenwich, made possible the accurate measurements of Bradley. In connection with a quadrant he was making for the Radcliffe Observatory at Oxford, he wrote to Prof. Hornsby in February, 1771: 'It will not be your interest to limit me in time, my intention is to do the best in my power, therefore must not be hurried.' Sisson is chiefly remembered by the eight-foot quadrant, now in the South Kensington Museum, which he made for the private observatory of George III at Kew.

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[1] Cf. *The British Association: A Retrospect*, Chap. V.

When dicussing the makers of scientific instruments of this period the name of William Herschel must not be omitted. He worked long and arduously developing the reflecting telescope. It is probable that the seven-foot telescope constructed by him in 1775 was a more effective instrument than that made by any previous constructor. He also made the large speculum reflector at Slough, the mirror of which weighed twenty-five cwt., and was four feet in diameter. He also developed the construction of eyepieces of high power, which are still in existence, and are excellent examples of his skill. His discoveries created a great demand for astronomical instruments, some of which he made himself whole, and others were made by the constructors previously mentioned or by their successors. It may safely be said that the prestige of the English scientific instrument-maker has never been higher than it was at the beginning of the nineteenth century. Ramsden was succeeded by William Cary (1759-1825), well known as a maker of sextants and theodolites; the firm is still in existence under the name of Cary Porter & Co. After the death of Ramsden the firm of the highest repute was undoubtedly that of Troughton, better known as Troughton & Simms. Edward Troughton (1753-1835) joined the business of his brother John, and continued it alone after his brother's death; he entered into partnership with W. Simms (1793-1860) in 1826. Owing to the ingenuity of Troughton and the firm's good workmanship,[1] a great demand arose for transit instruments and for equatorials made by Troughton and Simms. The firm was amalgamated with that of Messrs. Cooke, of York in 1922, under the name of Cooke, Troughton & Simms, Ltd. The early part of the nineteenth century saw a great development in the microscope, due primarily to the work of two men—Dr. Joseph Jackson Lister (the father of Lord Lister) and Andrew Ross. Tully, the optician, made for Dr. Goring the first achromatic objective. J. J. Lister pointed out that great accuracy of workmanship and complete steadiness in the stand were necessary in an achromatic microscope. His paper 'On some properties in achromatic object glasses applicable to the improvement of the microscope,'[1] led to the immediate improvement of English microscope objectives. The stand for Lister's microscope was made by James Smith to whom Tully had introduced him. The lenses were designed, if not actually worked, by Lister himself.[2] He afterwards financed Smith, who later entered into partnership with R. L. Beck, the firm becoming Smith & Beck, and later R. & J. Beck Ltd.

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[1] See *Phil. Trans. Roy. Soc.*, vol. LXXX, 1790. The actual instruments are exhibited in the Museum, South Kensington.

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[1] In a Report on the Progress of Astronomy during the present century made to the British Association at its second meeting in 1832, Prof. G. B. Airy stated (see p. 132) that the new method of graduating circles, published by Troughton in 1809 (*Phil. Trans. Roy. Soc.*, XCIX, p. 105) may be considered as the greatest improvement ever made in the art of instrument making.

Andrew Ross (1798-1859) using the work of Lister, produced some extremely good microscopes, showing great ingenuity in their design and construction. He introduced the method now generally employed for correcting for the thickness of the cover glass protecting the object, and also the long lever system of fine focussing adjustment. He was awarded in 1831, the Isis gold medal and the sum of fifty guineas by the Society of Arts for his work on the circular dividing engine.[1] Andrew Ross was succeeded by his son Thomas, who died in 1870. The firm is now well known under the name of Ross Ltd. One of the most distinguished firms of opticians during the middle of the nineteenth century was that of Powell & Lealand. Hugh Powell started in business as an instrument-maker about 1830, and was joined by his brother-in-law, Lealand, about 1840. For many years (*c.* 1835-1880), the instruments made by this firm were considered the best examples of English workmanship from both the optical and the mechanical points of view. Further development optically was unfortunately not possible owing to the difficulty of obtaining glasses of high refractive index; a difficulty so ably overcome by Abbé and his colleagues at Jena.

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[1] *Phil. Trans. Roy. Soc.*, 1830, p. 187.

[2] "Early Achromatic Microscopes by James Smith," by Reginald S. Clay and Thomas H. Court, *Journ. of the Roy. Micros. Soc.*, 1930, vol. 50, p. 297.

As far as is known there were not many makers of mercury and glass thermometers in this country. The manufacture of thermometers had always been an Italian industry and it is largely due to Italian craftsmen that London has now several manufacturers of accurate mercury in glass thermometers. Louis P. Casella began business in London under the name of Tagliabue & Casella in 1810; he was largely instrumental in introducing the clinical thermometer. One of his workmen, J. J. Hicks, later founded the firm bearing his name, and placed on the market the lens-front clinical thermometer and a large variety of meteorological instruments.

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[1] A full description by him of the Dividing Engine was published in the *Transactions of the Society of Arts*, vol. 48, p. 302.

Henry Negretti came from Italy about 1840 and joined with Joseph W. Zambra in 1850 to found the well-known firm of Negretti & Zambra, still carried on by the grandsons of the founders.

As the uses for scientific instruments increased so specialisation in manufacture became more important and firms began to specialise. Thus Elliott Bros., the immediate descendants of Francis Watkins (*c.* 1750) of microscope fame, became in the latter end of the nineteenth century the makers of electrical measuring instruments and electrical standards. The many references to the resistance coils made by this firm in the reports of the Electrical Standards Committee of the British Association show the high repute in which it was held.[1] To-day this firm stands in the forefront as manufacturers of electrical recording instruments.

Specialisation necessarily limits the range of the products made by a firm. Messrs. Evershed & Vignoles have concentrated on instruments for measuring resistance; Messrs. Nalder Brothers & Thompson and Messrs. Everett Edgcumbe on electrical instruments for the power station. The firm founded by Mr. R. W. Paul, which was later affiliated to the Cambridge Instrument Company, developed a large range of laboratory electrical measuring instruments. The London instrument makers are still able to maintain the traditions of Ramsden, in that Messrs. E. R. Watts & Son have developed a dividing engine, which automatically divides circles to an accuracy which a century ago could only have been obtained with the greatest effort.[1] The firm of Stanley & Co. must be mentioned not only as makers of surveying instruments, but because the founder of the firm (W. F. Stanley, 1829-1909) introduced a system of training for apprentices to the instrument trade which has had remarkable success. The firm of Adam Hilger (founded in 1874) is known everywhere for the high quality of its optical work, and is an outstanding example—if one were wanted—of the fact that there is always a demand for the best.

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[1] See for example page 327 of the *Reports of the Committee on Electrical Standards appointed by the British Association for the Advancement of Science* (Cambridge University Press).

These notes have been restricted to London instrument makers and thus the names of several well-known provincial firms have been omitted. Unfortunately, owing to the exigencies of space, it has not been possible to mention the names of several London firms of high repute. It is hoped that enough has been said to show that the instrument makers of London have endeavoured to play their part in the advancement of scientific knowledge.

The writer acknowledges the generous help that Mr. T. H. Court and Dr. Allan Ferguson have given him in the preparation of this note.

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[1] See 'Divided Circles,' *Dictionary of Applied Physics*, vol IV, p. 55, and 'A New Dividing Engine,' by G. T. McCaw, *Monthly Notices R.A.S.*, vol. 69, 1909, p. 226.

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